

## Article

# BIM Requirements in the Spanish Public Tender—Analysis of Adoption in Construction Contracts

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**Abstract:** The use of Building Information Modeling (BIM) is increasingly widespread within the Architecture, Engineering, Construction & Operations (AECO) sector. BIM allows the construction of a digital scale model of the asset to be built, ensuring the early detection of conflicts and interferences, enabling communication between the different participant agents, and facilitating the processes in the maintenance and management phase. Studies on the subject are many and varied. However, very few works refer to the inclusion of BIM in the public procurement stage, one of the most complex and competitive stages within the asset's life cycle. A bibliographic review has been conducted about the BIM situation in the AECO sector contracts, the existing problems and the possible solutions to implement. In the specific field of public procurement, Spain has made great progress, especially at the regional level. During 2020, a total of 440 tenders with BIM requirements were published, with an investment volume of EUR 752 million, which represents an increase of 230% compared to 2017. The aim of this research is to analyze the Spanish public procurement, highlighting the progress made so far in the implementation of this technology, as well as to develop a proposal of BIM requirements that, in general, could be used as a reference for tenders of the AECO sector in the country. With this objective, a selection of twenty relevant public tenders is made, covering both the building and infrastructure fields. The requirements address areas such as: BIM uses, BIM deliverables, model structure, Level of Development, Common Data Environment, classification systems, standards or quality control.



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**Keywords:** Building Information Modeling; BIM; procurement; public tender; contracts; BIM requirements

## 1. Introduction

Building Information Modeling has become an invaluable tool for the Architecture, Engineering, Construction & Operations (AECO) sector [1,2]. The use of BIM methodology allows the digital construction of an infrastructure, building or facility, covering all phases of its design, which makes its analysis and control easier [3,4]. Once completed, these digital models contain the precise geometry and data necessary to support construction and maintenance operations [3].

BIM methodology was first included in building projects to facilitate complex systems and it has achieved wide inclusion in the construction sector since then [5]. Since its inception in the 1970s, BIM has changed the traditional way of conveying design aims. Its implementation in the sector allows a lower cost and greater productivity, precision, communication, and efficiency [5]. Scientific literature endorses the recognition that the benefits of using BIM are an inevitable result of the adoption itself [2,6].

There is a large number of studies which describe the adoption of BIM during the design, construction or operation phases, but few of them focus on the tender phase [7]. The tender stage of a project can be a challenging one in the life cycle of an asset. BIM

models can be used for different purposes, such as estimating quantity take-offs and budgets, or to detect potential conflicts, interferences, and collisions. Furthermore, the methodology has the potential to structure deliveries and avoid loss of information during project development, ensuring the coordinated delivering of the owners' requirements and anticipating the impact of their decisions on the operative performance of infrastructures in the early stages of the project. The use of BIM could aid collaboration and communication in the tender process, reducing uncertainty and helping increase competitiveness [7]. However, there are still many bidding companies and organizations that avoid developing their projects using BIM models and processes on the basis of the tender documents for various reasons [8]:

- It is estimated that the effort for the development of offers based on BIM models in terms of technology and staff is high;
- There is a lack of competent staff to introduce and implement the methodology;
- Currently, there are not enough requirements for the introduction of BIM or the advantages derived from its use.

In the particular case of Spain, the inclusion of the methodology in public contracts is not mandatory. However, over the last few years there has been a progressive increase in the number of tenders with BIM requirements and the investment made. The objective of this document is to analyze the Spanish public procurement, highlighting the progress made so far in the implementation of the methodology, as well as to develop a proposal of BIM requirements that, in general, could be used as a reference for tenders of the AECO sector in the country, in order to prevent the publication of public contracts with insufficient definition of requirements, which in turn could generate conflicts between the participant agents. To that end, first, a general bibliographic review has been made in Section 2 about the BIM situation in the AECO sector contracts, the existing problematic in this regard and the possible solutions to implement. Then, in Section 3, the different milestones and advances produced in the country are listed in chronological order, highlighting the publications of handbooks and/or application guides, the creation of diverse organizations—both at the state and regional levels—consisting of experts in the subject, or the transposition of Directives 2014/23/EU and 2014/24/EU through Law 9/2017. An analysis of the national public sector tenders is accomplished in Sections 5 and 6, in order to detect the degree of inclusion of BIM requirements. Finally, a proposal of generic requirements to incorporate is established in Section 7, with the aim of facilitating the drafting of tenders, as well as ensuring the inclusion of the methodology in a clear, homogeneous way, in concordance with the nature of the asset and the volume of works.

## 2. BIM in Construction Sector Contracts—Literature Review

The implementation of any new process throws up a host of legal challenges, especially in an industry as multi-faceted as construction [9]. Bid prices generally are the sole basis for contractor selection around the world; for example, in North America and France, the lowest price bidder is selected and abnormal prices are excluded. Conversely, in Italy, Peru, Portugal, and South Korea, the two highest-priced and two lowest-priced bids are excluded [10]. In any case, this is not the only existing criterion for the selection of tenders. Legal regimes of public procurement also allow the criterion of the Most Economically Advantageous Tender (MEAT) [11]. This is the case of countries such as Italy, for example, where MEAT may be considered the standard criterion for tender selection. When using this criterion, the evaluation committee (a group of experts) has to consider several qualitative and quantitative evaluation criteria simultaneously: this takes quality, price, maintenance cost, life-cycle cost, technical merits, time, and extent and length of guarantees into evaluation items [12].

In countries such as Canada, there is significant progress in the efficient use of BIM in the procurement stage. In others, like the United Kingdom, BIM strategy shows that it could have a direct and tangible impact in the bidding phase. The client receives the advantages of this technology, which includes waste reduction and the avoidance of problems that

could lead to huge fines on either the contractor or other projects' stakeholders. However, there are certain struggles in BIM implementation in tender process such as regulation and legal considerations [10]. Existing conventional contracts do not cope with the BIM methodology. The fact that they are not adapted to the collaborative approach of BIM can result in the appearance of contractual disputes or conflicts, which become an obstacle to the effective use and promotion of its benefits [13].

Different authors, such as Alwash et al. [14] or Chong et al. [15], have studied the main problems caused by the fact that BIM is not included as a contract document. It has been concluded that all digital information, including that related to BIM, should be integrated as such to mitigate the potential legal risks that arise with the greater adoption of the methodology [16]. As stated by Winfield [9], there are limitations in BIM protocols. Consequently, they cannot be considered fully inclusive when it comes to legal issues. According to Chong et al. [15], the legal aspects to be considered are (1) structure and policy of the contract, (2) contractual relationships and obligations, and (3) BIM model and information security.

Regarding the first aspect mentioned, it must be said that the inclusion of BIM as a contractual document allows designers and contractors to coordinate work, as well as communicate with the owners and other interested parties for clarifications [16]. However, as the legal framework of traditional contracts is not designed for the inclusion of the BIM requirements of a project, there is a lack of clarity about roles and responsibilities required in this area. For this reason, it is necessary to create an alternative contract structure that responds to all these questions [15]. On the other hand, the implementation brings with it new risks, mainly related with the loss of shared data, its integrity and the detection of conflicts. These deficiencies can be detected and solved through the 'clash detection' procedure provided by BIM, although it may generate an additional workload, generally not included in the amount of the contract [13]. Therefore, in reference to the second legal aspect indicated, if the contractual relationships and obligations do not exist or are not defined in the contract, there is no legal liability [15]. Likewise, ambiguity in the clauses leads to conflicts between the parties [13].

Another problem when including BIM methodology in the contract of a project or construction work refers to the ownership of generated models [13]. Winfield [9] claims that, considering the evolving and changeable nature of the models—especially during the design phase—there is no need for them to be part of the contract documents. However, these issues could go against the criteria of the designer, worried about the loss of their intellectual property rights. Furthermore, what makes the ownership of models in BIM projects even more complex is the fact that they are developed through collaboration between different parties, so each of them will claim ownership of their contribution. According to Ragab and Marzouk [13], the intellectual property of each element must be determined in the contracts in order to prevent subsequent conflicts. A solution that would respond to the problem described could be that presented in article 7 of Document B101-2017 of the American Institute of Architects, 'Standard Form of Agreement Between Owner and Architect', which establishes that authors of models own the copyright of their products, but they must grant a nonexclusive license to the project owner for purposes of constructing, using, maintaining, altering and adding information [17].

Lastly, since the information from BIM models is digitalized and parameterized, it can be extracted easily and totally or partially reused. This raises a new issue in relation to BIM models and information security, which is how to protect this information. In this regard, it is necessary to devise a data management policy for all stages of project development, in order to avoid the exchange of unnecessary and incorrect information in projects. This data management policy must also approach interoperability issues between different software tools [15].

In light of the above, and according to the study by Chong et al. [15], the minimum legal aspects that could be used as contractual provisions associated with the implementation of BIM would be:

1. The scope and requirements of the project must be established by means of a specific BIM standard contract form;
2. The relationship between client, designers and contractors must be clearly defined in the contract;
3. Digital data must be protected to maintain their integrity;
4. A BIM manager role should be assigned for the project;
5. Data providers (designers or contractors) must be responsible for the data inserted in the model;
6. Digital data or information should be treated as part of the contract document;
7. The contract must define the functions and scope of the construction works for all parties involved in the project;
8. The contract must define the BIM objectives and quality checks for different stages of development;
9. The owner of the model or the client can use, access and reproduce the model if permission has been obtained from the copyright owner.

As a summary of the above, the need to adapt the structure of traditional contracts to the requirements of BIM methodology is emphasized, including issues such as roles and responsibilities of the agents involved in the process, or the contractual relationships and obligations applicable in each case. According to different authors, the existence of ambiguities can cause conflicts among the parties, thus the correct definition of these matters would avoid disputes and facilitate the resolution of risks and interferences detected in the models. In relation to disputes, it is also necessary to clearly define the ownership and intellectual property of models, ensuring the conformity and compliance of both parties' rights. Finally, the establishment of a data management policy will ease the security and integrity of the information contained in the models.

### 3. Spain's Progress to BIM Implementation

The development of the BIM methodology in several countries is mainly related to the strategy of the different governments. For this reason, it is essential that they establish a BIM policy framework with mandatory requirements that become a boost for research and development [18]. According to the Methodology Handbook for Calculating Costs and Benefits for the Use of Building Information Modeling in Public Tenders prepared by the EU BIM Task Group [19], the public sector can benefit from BIM adoption in three distinct stakeholder roles:

1. Public procurer or an infrastructure and estate owner concerned with the project phase;
2. Public infrastructure and estate owner concerned with the operations and maintenance phase;
3. Policymaker concerned with the development of legislation, policy, regulations or standards for improving performance of the sector or built environment.

A study by Kassem and Succar (2017), on the macro adoption of the methodology, shows how countries are increasingly embracing it—the Netherlands, China, the United States, and the United Kingdom being those that are in the most advanced stage among the different nations analyzed [7]. At the European level, Finland, Sweden, Norway or the above-mentioned Netherlands published their first public initiatives to promote the use of digital processes for the generation and management of construction information. This is the case of PAS 1192-2 and PAS 1192-3 in the UK or those derived from the Senate Properties of the Finnish government [20]. On the contrary, the Czech Republic, Lithuania, Cyprus or Greece have a lower implementation rate [21].

In the case of Spain, the es.BIM Commission—currently the Interministerial BIM Commission (CBIM)—proposed, in 2015, the following milestones for the implementation of BIM at the national level:

- Recommended use of BIM in public tenders: 12/03/2018;

- Mandatory use of BIM in public building tenders: 17/12/2018;
- Mandatory use of BIM in public infrastructure tenders: 26/07/2019.

However, the government changes in the affected areas have generated the stagnation of this proposal and the indicated deadlines have not come into effect. Nevertheless, there are great advances at an autonomic level—such as the publications of handbooks and application guides—regions such as Catalunya, Comunitat Valenciana or Euskadi standing out.

Taking a historical trajectory of how BIM was introduced in Spain, it should be noted that in 2012, the Spanish chapter of buildingSMART was officially constituted. Additionally, within the framework of the First BIM National Congress (EUBIM), a standardization initiative named “uBIM” was presented, whose initial objective was the development of a guide in Spanish for BIM users. The first thirteen documents which constitute the guide were released by buildingSMART Spanish Chapter at the end of 2014 [21].

With Directive 2014/24/EU, for the first time, the European Union urges its member states to consider the use of technology in order to modernize and improve public procurement processes, giving greater importance to the investment to be made throughout the entire life cycle of a construction or asset [22]. To some extent, European legislators took into account the experiences of Finland and the United Kingdom to put emphasis on them later [20].

In mid-2015, the Government of Spain created the es.BIM Commission, and the Catalunya Institute of Construction Technology (ITeC) created the Build the Future Commission [20]. Three years later, in 2018, the BIM Euskadi Commission was established in Euskadi within the Construction Cluster Eraikune.

The es.BIM Commission, dependent on the Ministry of Development, organized through working groups of professionals in the sector, published several documents: the “Guide for the Development of the BIM Execution Plan” (2018), “Roles in BIM Processes” (2017), the “User Guides” (2018), among others [23]. This commission also created a BIM Tenders Observatory, with quarterly reports on the degree of tender in different public administrations [20].

The transposition into the Spanish legal order of Directives 2014/23/EU and 2014/24/EU was made through Law 9/2017, on Public Sector Contracts of the Spanish state, indicating the following in article 6 of its fifteenth additional provision:

“For public construction works contracts, construction works concessions, services and projects tenders, and in mixed contracts that combine elements thereof, the contracting authorities may require the use of specific electronic tools, such as digital modeling tools of building information (BIM) or similar tools.”

BIM methodology, apart from the Law on Public Sector Contracts, is present in diverse national strategies such as the “National Reform Program” (2019), the “Green Public Procurement Plan” (2019), the “Spanish Strategy for the Circular Economy” (2020) or the “Digital Agenda 2025” (2020) [24].

As of the publication and entry into force of Law 9/2017, different regional public administrations, such as those of Catalunya and Euskadi, had the sufficient legislative framework to require the use of the methodology in their contracts. In the region of Catalunya, the obligation and its use are regulated, determining the contracts in which the BIM methodology must be applied. It is the case of the construction contracts with budgets greater than EUR 5,350,000, as well as the service contracts associated to a construction contract with budgets greater than EUR 214,000 [20].

By the end of 2018, the Government of Spain had created the Interministerial Commission for the incorporation of BIM methodology in public procurement. This revealed a substantial change in tactics, going from the Bottom-up strategy of es.BIM, in which the administration itself provided the instructions to follow, to the Top-down strategy of the new Interministerial BIM Commission, where the private agents involved in the process were in charge of introducing the proposals to improve the processes.



According to the motivation for the creation of this Interministerial Commission, the public interest derived from the implantation of the BIM methodology in public procurement lies mainly in that it allows better control of project costs. This has repercussions in their savings and involves a remarkable increase in the efficiency of investment and public procurement [22].

Organizations such as Aena—the public company for the management of airports of general interest in Spain, Puertos del Estado—the National Port Authority of Spain or ADIF (Administrator of Rail Infrastructures), all of them dependent on the Ministry of Transport, Mobility and Urban Agenda—are developing their strategies for BIM implementation. The Public Sector Contracts Law also allows public entities from any field (national, regional or local) to decide to require the use of BIM in their construction projects and works, either as a requirement or as a valuable element in the offer [25].

In 2018, the ITeC and the Generalitat published the “White Book on the Strategic Definition of BIM Implementation”, prepared by members of the Coordination Group from the Build the Future Commission of the Catalunya region [26]. Additionally, in June 2019, the Generalitat published its Guide and BIM Manual. With these documents, it intended to establish general guidelines on the framework of the BIM methodology and specifications that could be used by the organization itself or any of its entities in the development of proceedings [27].

In June 2019, the Puertos del Estado public company published its own BIM Guide, in order to serve as a support for the different national Port Authorities, as well as for the rest of the agents involved in the fields of infrastructure management and operation [28].

In Euskadi, the Euskal Trenbide Sarea/Basque Railway Network (ETS) entity published its BIM Manual in April 2020. It was developed in a report and several annexes, and was intended to be used in all stages of intervention (design, construction and maintenance) with the purpose of defining the framework for the production and delivery of BIM information in each phase of the project [29]. Additionally, in the same year, the Euskadi BIM Observatory published the first report on the implementation of BIM methodology in the region, collecting the data corresponding to the public building sector in 2019.

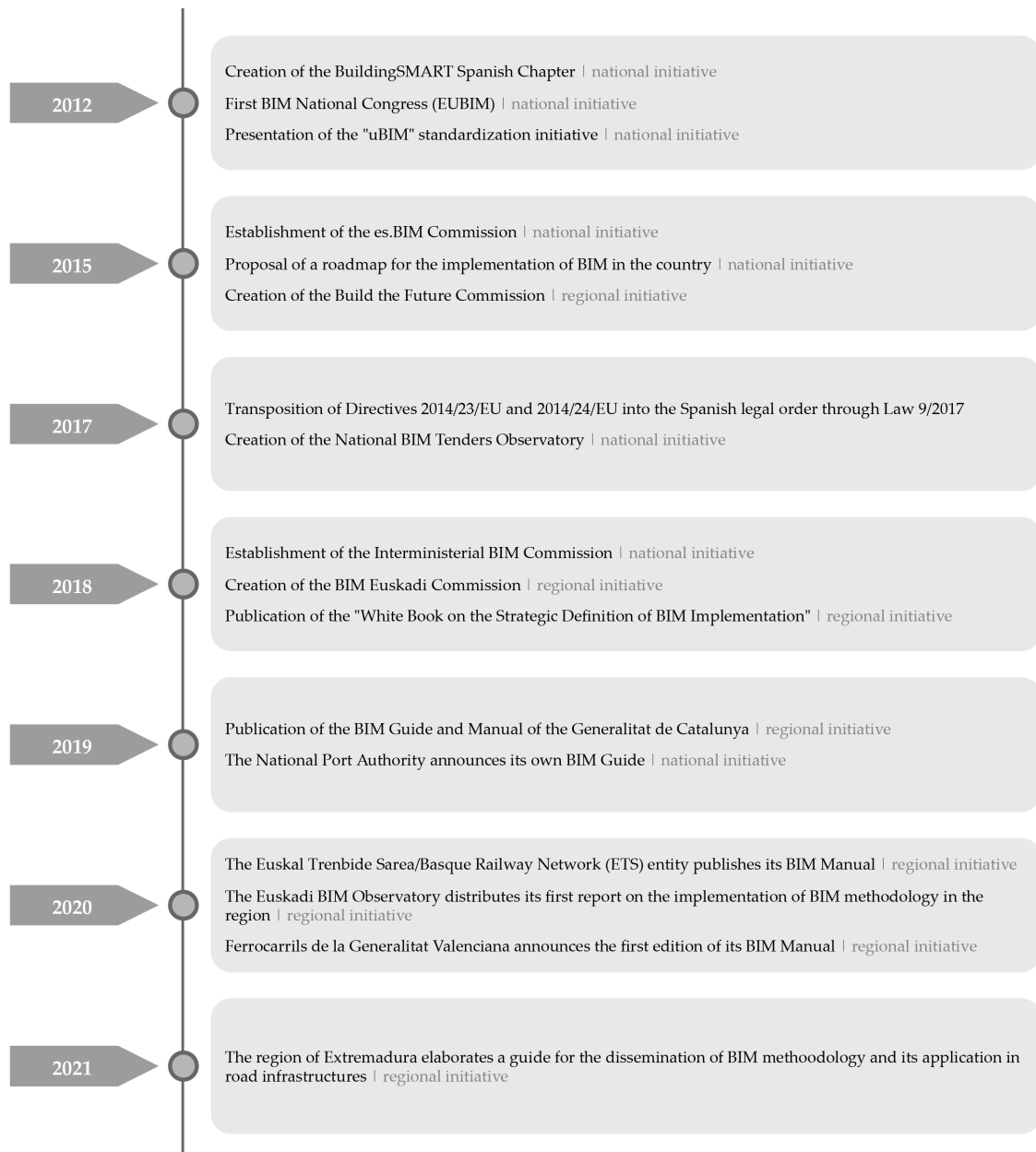
In October 2020, the Comunitat Valenciana, through Ferrocarrils de la Generalitat Valenciana (FGV)—a public company dependent on the Valencian Generalitat—announced the first edition of its BIM Manual, consisting of two volumes and a set of additional documents; the first volume containing the entity strategy for the implementation of BIM and the second, the methodology to apply [30].

In the region of Andalucía, the Regional Department of Development, Infrastructure and Land Planning made various documents available: the BIM requirements demanded for tender documents for the drafting of projects and execution of construction works, a BIM Execution Plan template, and a supervision report model of the BIM Execution Plan [31].

In 2021, in the region of Extremadura, the Regional Department of Mobility, Transport and Housing elaborated a guide for the dissemination of BIM methodology and its application in road infrastructures with the aim of introducing and establishing this procedure in the projects developed within the regional roads network.

This section provided an overview of the set of initiatives performed in the Spanish scenario in relation to the BIM methodology (Figure 1). While a large number of European countries have developed a national strategy—such as UK, Germany or France—the roadmap initially proposed in Spain suffered stagnation due to the government changes that took place. In fact, BIM application is not mandatory in the country, in contrast to places like Finland, in which its use was consolidated in 2007 as mandatory for government buildings; or Sweden, where BIM has been obligatory in the strategy implemented by the Swedish Roads Administration since 2017 [32]. In spite of that, large-scale proposals have been carried out in Spain, including the constitution of the buildingSMART Spanish Chapter, the ‘uBIM’ standardization initiative, the creation of the Interministerial BIM Commission or entry into force of Law 9/2017, on Public Sector Contracts. The latter has

been a milestone, since it is the first state law to mention the methodology. However, no implementation dates or stages have been established in the national legal framework, contrary to what occurs in countries such as Italy and its Ministerial Decree no. 560-2017. Lastly, although not all regions in Spain have evolved at the same time, at a regional level, important advances have been made, especially in Catalunya, Euskadi or the Comunitat Valenciana, which have created their own BIM handbooks and guides. The first two regions also have sufficient legislative framework to be able to demand the use of BIM technology in their contracts.



**Figure 1.** Advances in the adoption of BIM in Spain.

Due to the lack of a BIM mandate in the country and the stagnation of the initial roadmap for the implementation of the methodology, it is perceived that there are few references that can be used for public administrations to define BIM requirements in the tender contracts based on a single criterion at the national level, and appropriate to the needs of the asset and the phase of the life cycle for which they are drawn up.

#### 4. Methodology

Although the mandatory use of BIM in Spain has not been established in the Public Sector Contracts Law, certain regions have proactively implemented practices related to the methodology, such as in guides or handbooks. As a consequence, there is a notable increase in the inclusion rate of BIM requirements in national public sector tenders. Therefore, a quantitative analysis of the tender contracts promoted so far is necessary in order to identify their strengths and weaknesses. The analysis proposed in this research (Figure 2) provides information about the most usually BIM requirements requested in the Spanish public sector contracts. With these data, a proposal is made of requirements that should be considered when drafting a contract so that it is consistent with the phase of the life cycle to which it corresponds, the needs of the asset, and the qualification of the participant agents.

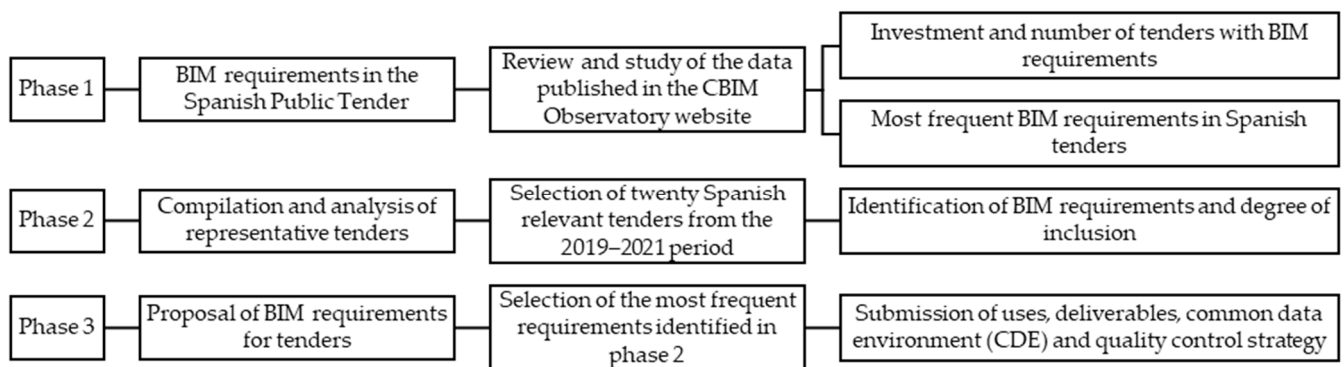


Figure 2. Phases of the applied methodology.

In a first phase, a general study of the inclusion of BIM in Spanish public procurement is carried out. An analysis of investment and number of tenders with BIM requirements is made during the period 2017–2021. Additionally, a summary of the most requested BIM requirements is provided in the total computation of the BIM tenders published during the period January 2020–August 2021 in Spain. These data were collected from the official website of the BIM Public Tenders Observatory (CBIM) [33,34], created by the Interministerial Commission. The requirements considered have been: uses, deliverables, model structure, level of information, Common Data Environment, classification systems, standards or quality control.

The second phase of the methodology research has consisted of the selection of recent tenders to analyze the included BIM requirements. Tenders were taken from the BIM Observatory section of the buildingSMART Spanish Chapter website, since it allows them to be ordered based on the type of contract and their estimated budget, among others. Contracts' documentation and the rest of data were collected from the official websites of the Public Procurement Platforms of the State, Catalunya and Euskadi. A total of twenty tenders have been chosen, with an estimated contract amount of between EUR 187,000 and EUR 24.5 M. This selection has been made choosing the relevant tenders and taking into account that the investment volumes of higher amount, in general, present a higher definition of BIM requirements. All of them were launched to public competition procedure during the 2019–2021 period, the results being an accurate projection of the sector's outlook at the time of preparing this study. Fourteen of the tenders refer to service contracts, understood as those referring to the project development—planning and design—and operation and maintenance stages. The six remaining contracts studied are for works' construction. Additionally, half of the tenders analyzed belong to the building sector and the other half to the infrastructure sector. A group of BIM requirements have been selected, all of them representative of good praxis when implementing the methodology, and the contracts of the chosen tenders have been examined, in order to see which of these were included and, in this case, to which degree. The BIM requirements considered have been: objectives, uses, Levels of Development (LOD), deliverables, Common Data Environment



(CDE), CDE workflow, documentation structure, nomenclature, standards, classification systems, roles, and the quality assurance strategy of the models developed. All of them are defined in Appendix A for a better understanding.

In the third and final phase, a proposal for general BIM requirements to be included in specifications is made. For this, the most frequent requirements have been selected. The proposed scheme refers to uses, deliverables, Common Data Environment (CDE) and quality control, as they are those that generate more confusion at the time of their establishment. In the case of uses and deliverables, they have been classified according to the life cycle phase to which they belong, as indicated above.

## 5. BIM Requirements in the Spanish Public Tender

The legal regulations of Spanish public sector contracts are determined by Law 9/2017, on Public Sector Contracts. The concept of BIM within the Spanish legal system appeared for the first time in this law. Despite this, its inclusion is not very concise and is misleading. First of all, because it is conceived as a tool and not as a work methodology. Secondly, because the section in which it is incorporated refers to the time of bid submission, and there is no mention of the remaining stages of the asset life cycle. Likewise, standards of any kind are established or agreed upon, so the inclusion of BIM in public administration contracts is not mandatory a priori. However, these contracts could require their incorporation in the tenders based on the principles of administrative discretion, public interest and no discrimination, alluding to the criteria for the award of contracts determined in article 145 of the law, which reward aspects such as the cost of the life cycle, effectiveness, or even environmental or social aspects [35–37]. All of them, given the collaborative and digital nature of BIM, could be achieved with its application.

A common figure in Spanish administrative procurement is the contract specification documents. These contain all the clauses that will govern the administrative contract, as well as the rights and obligations that correspond to each party. The procurement files are integrated by two types of specification documents: the specific administrative clauses document and the technical specification document (Figure 3). The use of the methodology should be indicated in the specific administrative clauses document as the subject of the contract, not as an additional provision or improvement thereof [36], since the improvements must necessarily be linked to the subject of the contract.

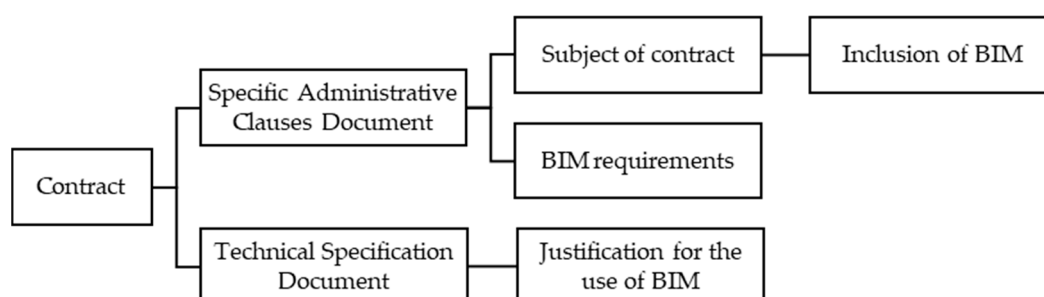


Figure 3. BIM inclusion in Spanish public procurement.

The contract must also consider the BIM requirements expected from the contractor. The owner should decide them, considering not only its capacity, but also the capacities of its common suppliers. If the level of demand is too high, the tenders can remain unawarded or without competence [38].

Regarding admissible formats, public administrations must adhere to both the principle of technological neutrality and the provisions of Law 9/2017, in respect to “all the information contained in the contracting entity profiles will be published in open and reusable formats, and will remain accessible to the public for a period of time not less than 5 years”. Thus, the result of the application of the methodology, when it comes to public contracts, should be an IFC file that complies with the interoperability standards of the

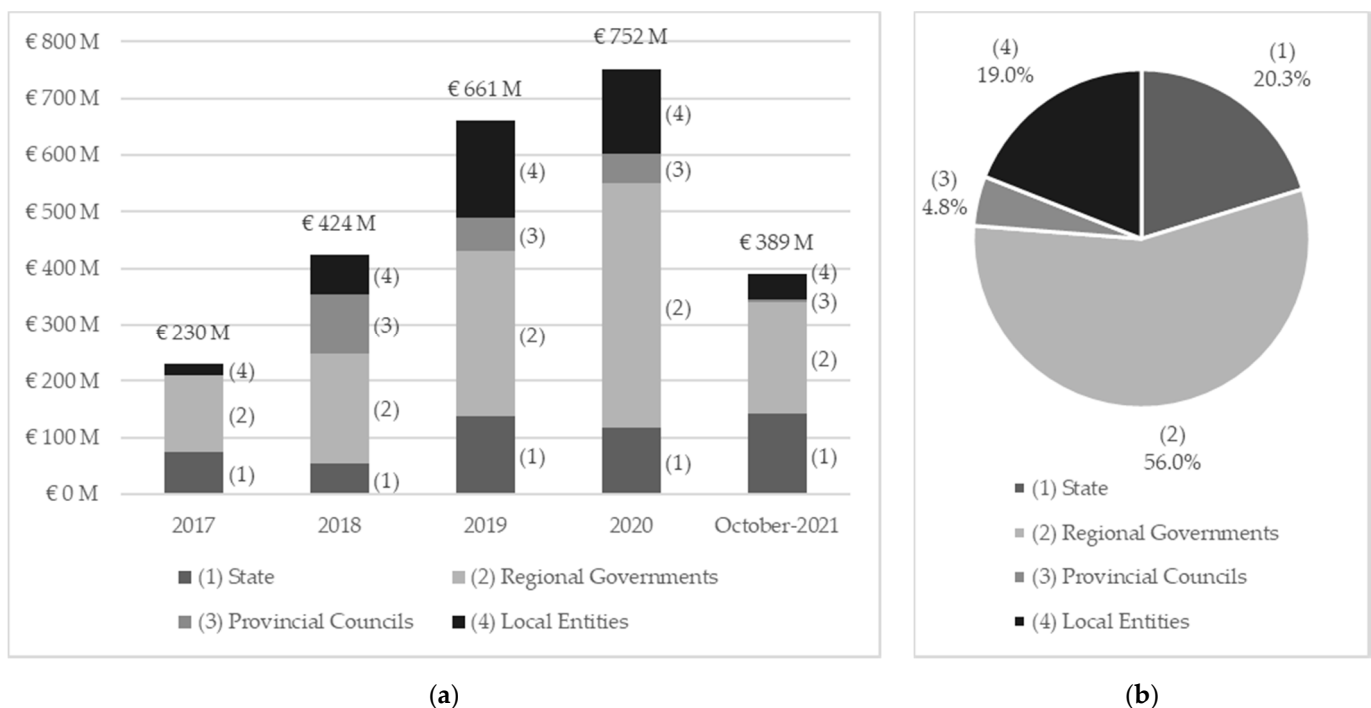
regulation. In any case, the administration may require the delivery of the proprietary BIM format in the contract, but never force the use of a specific format [36].

The way in which technology is legislated, as well as the type of public contracts regulated in Law 9/2017, prevent the connection and cooperation between the participant agents in the different stages of the life cycle of an asset. The BIM model is created and concludes in the process of the drafting of the project, because the phase of works' management and subsequent actions are tendered separately, passing into other teams' hands. It is concluded, for instance, that BIM methodology is not prepared for the Law on Public Sector Contracts [35] and vice versa.

### 5.1. BIM Observatory of Public Tender in Spain

The BIM Public Tenders Observatory (CBIM), created in May 2017, is in charge of analyzing the tenders announced in Spain in order to identify those that contain BIM requirements [33]. It publishes quarterly reports that analyze the status of Spanish public tender based on the data collected.

In report number 13, referred to the fourth quarter of 2020, a progressive increase is shown, both in number of tenders and in the investment made. In 2020, a tender budget volume of EUR 752 million was reached throughout the year, and a total of 440 tenders were published, thus being the year with the highest investment of the period 2017–2021 (Figure 4a). Of the tenders registered in the mentioned year, 15% correspond to the State, 18% to the Local Entities, almost 5% to the Provincial Councils, and 62% to the Regional Governments. By sectors, 48% of the contracts tendered with BIM requirements refer to buildings, while the remaining 52% are for infrastructures.



**Figure 4.** Evolution of tenders in Spain 2017–2021: (a) Annual investment volumes for the period; (b) Distribution of tenders by level of administration. Source: Own elaboration based on [33].

A detailed analysis of the data indicates that the different levels of administration experienced a positive evolution in the number of BIM tenders published in the period 2017–2019. However, during 2020, there was a decrease in them at state and local level, and only the regional administrations showed a constant evolution in the number and the investment made. The region that allocated the largest budget in this matter was, by far,

Catalunya, with EUR 287.92 million. It is followed by Madrid (EUR 82.04 M), Aragon (EUR 77.89 M), the Comunitat Valenciana (EUR 61.10 M), and Andalucía (EUR 30.24 M).

The volume of BIM tenders, from 2017 to October 2021, distributed by administration level, is detailed in Figure 4b: 20.3% corresponds to the State, 19.0% to the Local Entities, 4.8% to the Provincial Councils, and 56.0% to the Regional Governments. By sector, 28.3% of tenders from the infrastructure sector were promoted at a regional level, while in the building sector, it was 27.7% [34].

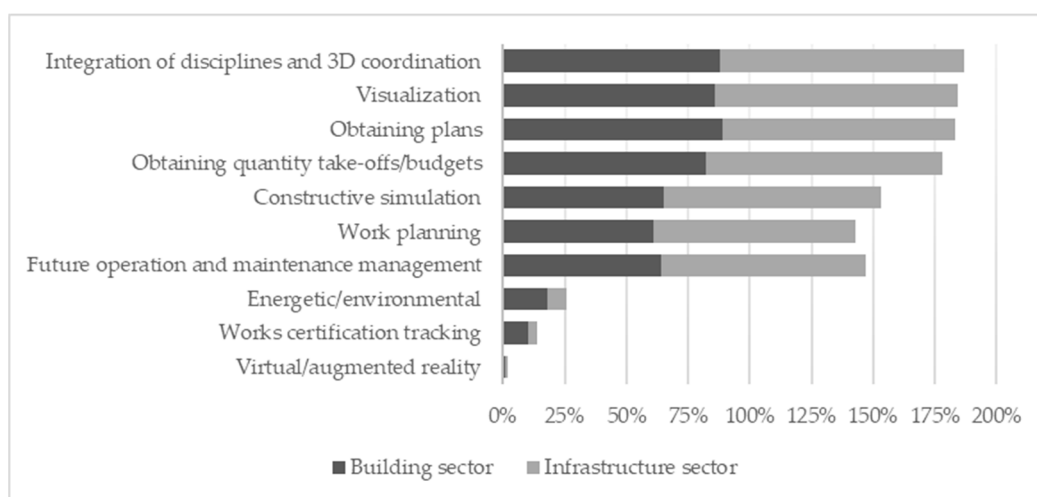
## 5.2. Analysis of Tender Requirements in the Spanish Public Sector

The CBIM Observatory groups the tenders according to the year of publication and the level of the public administration that promotes them: State, Local Entities, Provincial Councils, and Regional Governments. It also makes a classification based on the sector (building or infrastructure) and the type of BIM requirements that its specification contract documents include.

The data shown by the Observatory refer to the tenders promoted from 2020 onwards. They highlight the high rate of definition of BIM requirements in the specification contract documents of public tenders in the country. The definition of requirements covers areas such as BIM uses, BIM deliverables, model structure, level of information, Common Data Environment, classification systems, standards or quality control.

### 5.2.1. BIM Uses

The tenders promoted for the building sector during the period January 2020–August 2021 define BIM uses in 61% of the cases. This is a slightly lower percentage than the infrastructure sector, which includes these requirements in 85% of the published tenders. The most common BIM uses in the first sector pointed out are obtaining plans (89%), integration of disciplines and 3D coordination (88%), visualization (86%), and obtaining quantity take-offs/budgets (82%). The least frequent, on the other hand, are energetic/environmental (18%), works certification tracking (10%), and virtual/augmented reality (1%). In relation to the infrastructure sector, the requested BIM uses are similar, in an even higher percentage in some cases (Figure 5).

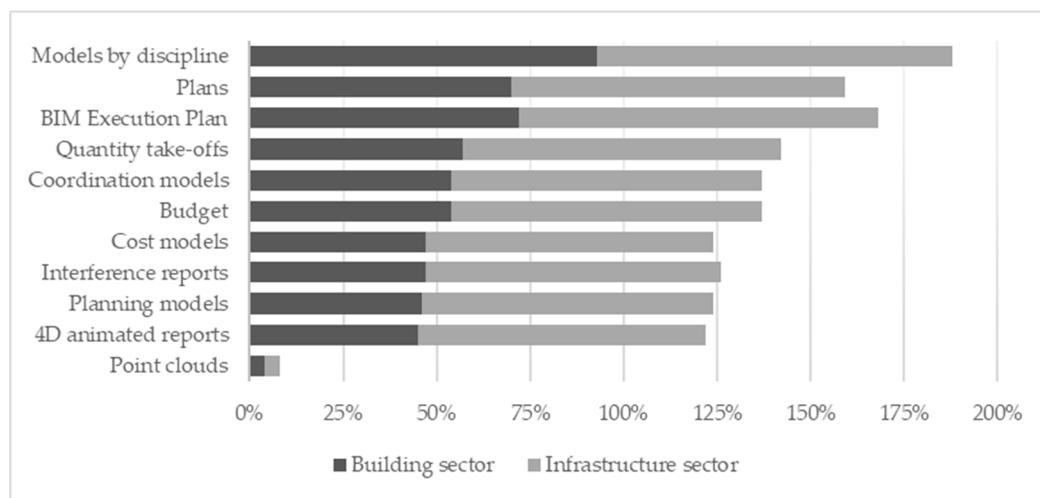


**Figure 5.** Inclusion of BIM uses in contracts by sectors. Source: Own elaboration based on [33].

### 5.2.2. BIM Deliverables

As regards to BIM deliverables, the inclusion percentages in public sector tenders are 71% in building and 85% in infrastructures. The most frequent deliverables in the first sector are models by discipline (93%), BIM Execution Plan (72%), and plans (70%), and the least cited are planning models (46%), 4D animated reports (45%), and point clouds (4%). In the infrastructure sector, the outstanding deliverables are BIM Execution Plan (96%),

models by discipline (95%), plans (89%), quantity take-offs (85%), coordination models (83%), and budget (83%), among others (Figure 6).



**Figure 6.** Inclusion of BIM deliverables in contracts by sectors. Source: Own elaboration based on [33].

### 5.2.3. Model Structure

The model structure is determined in 80% of the contracts of the building sector. In 18% of cases, no structure is established, and in the remaining 3%, it is left to the bidder's choice. In the infrastructure sector, the percentage of definition of the model structure is quite high at 93%, while 3% of the contracts do not determine requirements in this matter. In the remaining 4%, the definition of the model structure is left to the bidder's choice.

### 5.2.4. Level of Information

The tenders promoted for the building sector define levels of information (graphic and non-graphic) of the models in 63% of the cases. This is a lower percentage than in the infrastructure sector, which includes these requirements in 84% of the published contracts. Regarding the levels of graphic information in the field of building, these are specified by element in 72% of the cases, generally in 10%, and by discipline in 15%. The percentages for non-graphic information are very similar to the previous ones, specifying levels by element in 71% of the cases, generally in 9%, and by discipline in 8%. In the infrastructure sector, the levels of graphic information are defined by element in 92% of the contracts, generally in 3%, and by discipline in 4%. The levels of non-graphic information are determined by element in 93%, generally in 3%, and by discipline in 2%.

### 5.2.5. Common Data Environment

The tenders published in relation to the building sector establish a Common Data Environment in 50% of the cases. The definition percentage in the infrastructure sector is higher at 77%. In the first sector, 85% of the contracts demand that this collaborative platform be proposed by the bidder, 11% require that it be provided by the client, and the remaining 4% have certain collaboration requirements, but the use of an environment or platform is not contemplated. In the second sector, it is specified in 95% of the cases that the bidder is the one who proposes a Common Data Environment, while 4% determine that it is the client who must provide it.

### 5.2.6. Classification Systems

On the subject of classification systems, it should be noted that, besides the already known international systems, a classification system named GuBIMclass has been developed in Spain [39]. GuBIMclass was created by the BIM Users Group of Catalunya (GuBIMCat) and adapted to the reality of the construction sector in the country.

Additionally, 57% of the building sector contracts define a classification system. This percentage is 78% in the case of infrastructure contracts. The most requested classification systems in the case of the first sector are the above-mentioned GuBIMclass with 85%, and Uniclass, with 7%; 1% of the contracts have defined their own classification system, while the remaining 3% have indicated nothing in this regard. In the field of infrastructures, these percentages are: 87%, GuBIMclass; 4%, Uniclass, and 1%, Omniclass. Moreover, 4% of the contracts have established their own classification system and another 4% have not determined any (Figure 7).

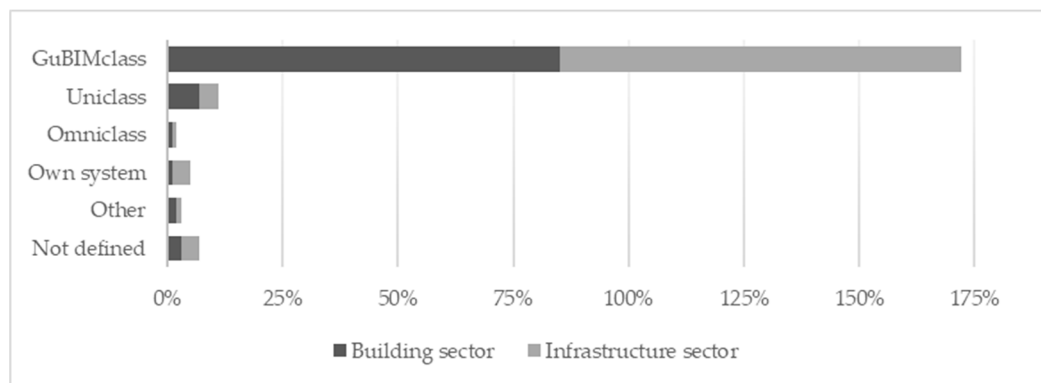


Figure 7. Definition of a classification system in contracts by sectors. Source: Own elaboration based on [33].

#### 5.2.7. Standards

Of the published tenders with BIM requirements, 65% of those belonging to the building sector and 72% relative to the infrastructure sector determine the use of standards. Since most of the tenders analyzed are previous or contemporary to the publication in Spanish of the ISO 19650 series, the results obtained from the analysis carried out show the majority required other types of standards, although a slight rising trend in the claiming of its use begins to be observed. Regarding the building sector, among the most common are: BS1192:2007+A2:2016, with 88% of definition in contracts; PAS 1192-5:2015, also with 88%; UNE-EN ISO 19650-1:2019, with 4%, and UNE-EN ISO 19650-2:2019, with another 4%. Additionally, 98% of the contracts request other standards. In the field of infrastructures, these percentages are: 94%, BS1192:2007+A2:2016; 95%, PAS 1192-5:2015; 4%, UNE-EN ISO 19650-1:2019, and 3%, UNE-EN ISO 19650-2:2019. In this case, also, 95% of the contracts ask for other standards.

#### 5.2.8. Quality Assurance

Tenders promoted for the building sector define the quality assurances or controls that must be carried out previous to the submission of the models in 55% of cases. In tenders of the infrastructure sector, this percentage is 74%. The most requested controls in the first sector are those relative to levels of information, with 98%; structure of the model, with 94%; classification, with 93%, and changes in the model, with 3%. In the field of infrastructures, these percentages are: 99%, structure of the model; 98%, classification; another 98%, levels of information, and 2%, changes in the model.

### 6. Analysis of the Selected Tenders

The selected twenty tenders analyzed in this section have been taken from the BIM Observatory section of the buildingSmart Spanish Chapter website. All of them have been launched to public competition procedure during the 2019–2021 period. In order to conduct an equitable study of the AECO industry in the country, half of the tenders belong to the building sector and the other half to the infrastructure sector.

The total of the tender contracts define BIM uses within the requirements in this matter. However, although the uses are intrinsically linked to the objectives, two of the tenders



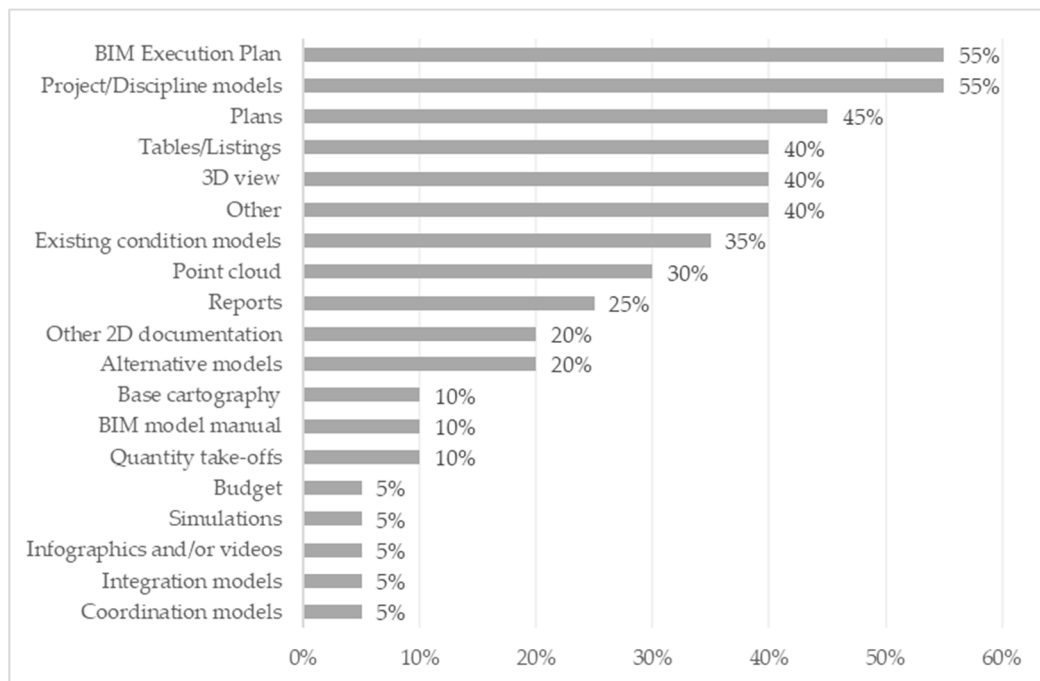
do not determine them. Among the most requested uses of models are the integration of disciplines and 3D coordination (70%), data visualization (60%), obtaining quantity take-offs/budget (55%) or the generation of plans and 2D documentation (50%). It is also worth highlighting the percentage of tenders that require models for the future operation management and maintenance of the asset (45%) (Figure 8).



**Figure 8.** BIM uses identified in the analyzed contracts.

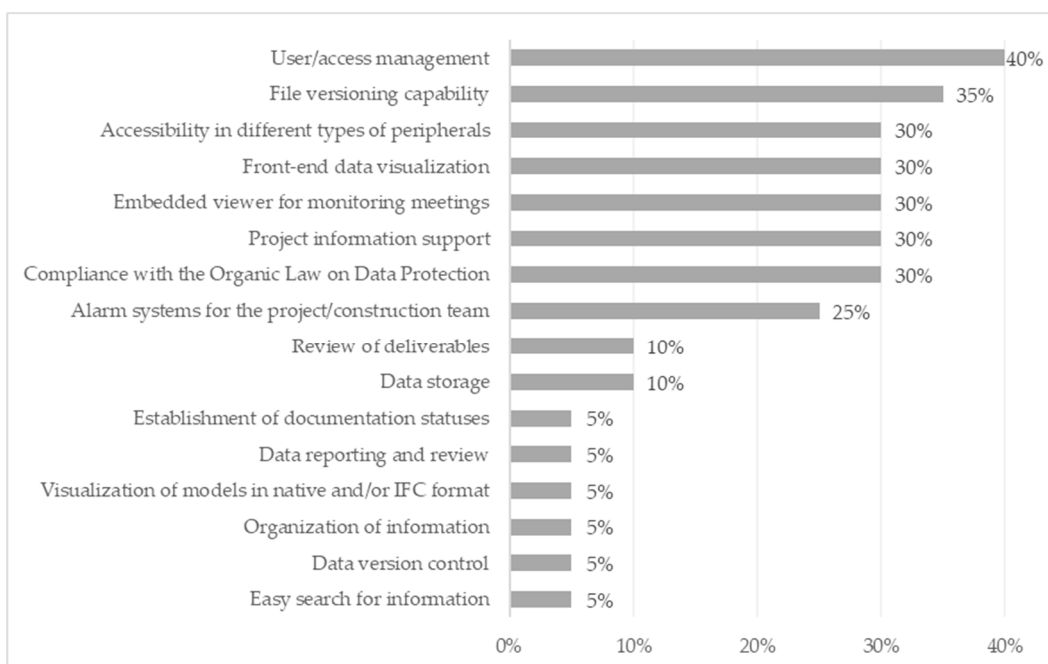
Regarding the levels of development, almost half of the contracts require their use (55%). The most required level is LOD 300 (45%), followed by LOD 200 (40%), LOD 500 (25%), LOD 400 (15%), and LOD 350 (5%).

The BIM deliverables are included in the total count of the contracts examined. The most requested are the project/discipline models (55%) and the BIM Execution Plan (55%); also worth mentioning are plans (45%), models of existing conditions (35%) or models of alternatives (20%) (Figure 9).



**Figure 9.** BIM deliverables identified in the analyzed contracts.

The Common Data Environment (CDE) is defined only by 40% of the selected tenders. However, the workflow, which is closely related to the previous concept, has a higher inclusion percentage in the contracts at 70%. Among the most noteworthy characteristics requested for the CDE are user/access management (40%), file versioning capacity (35%), accessibility in different types of peripherals (30%), and alarm systems for the project/construction team (25%). In contrast, the easy search for information, the organization of information or the visualization of models in native and/or IFC format are the least required, with each having values of 5% (Figure 10).

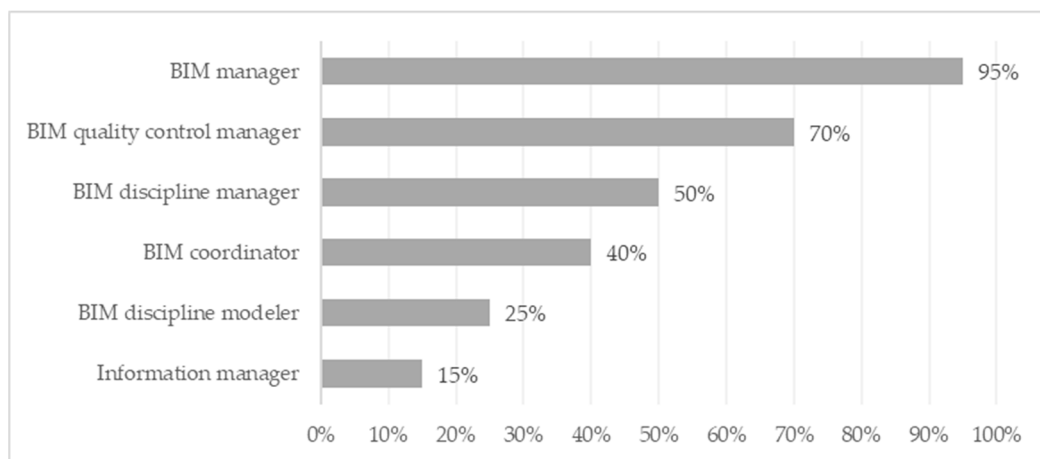


**Figure 10.** Characteristics of the CDE requested in the analyzed contracts.

In respect of the workflows' states, the most required are the work in progress, shared and published/delivered, with 70% each. The archived status is also quite frequent, with 65% inclusion. Finally, there is the approved status, defined in 5% of the cases.

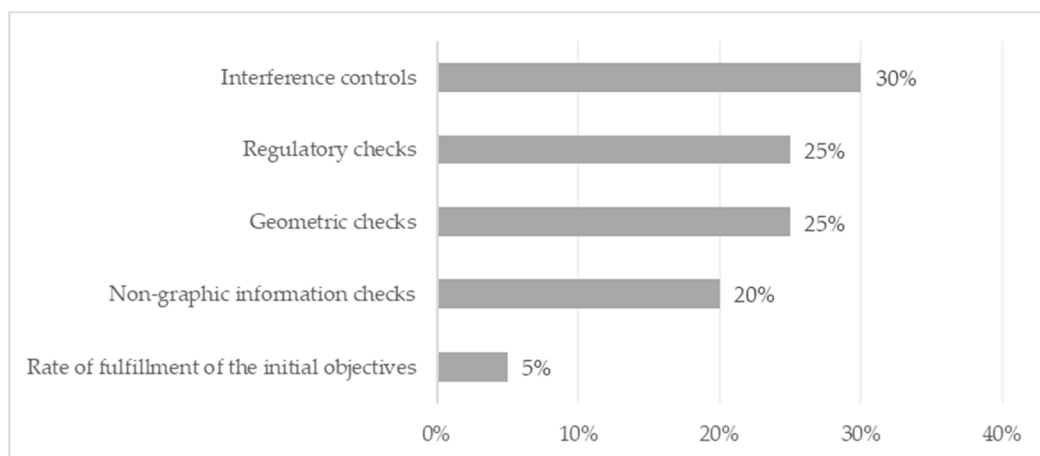
The structure of the documentation is determined in 90% of the specifications; the definition of the nomenclature to be used in the files is almost at the same inclusion percentage, with 85%. On the other hand, the standards are included in the total of the selected tenders. The classification systems are incorporated in a smaller percentage of the contracts at 70%.

The roles are set in 95% of the cases, and among the most notable are the BIM manager (95%), the BIM quality control manager (70%), and the BIM discipline manager (50%) (Figure 11).



**Figure 11.** BIM roles identified in the analyzed contracts.

Finally, 75% of the specifications define a quality assurance strategy for the models to be developed. The most requested verifications are interference controls (30%), regulatory and geometric checks (25% each), and non-graphic information checks (20%) (Figure 12).



**Figure 12.** Quality controls identified in the analyzed contracts.

## 7. Proposal of BIM Requirements for Tenders

Based on the documentation analyzed and detailed in the previous section, and the study of different BIM guides and handbooks published at the national level in Spain [27,28,30,40–42], a proposal for general BIM requirements to be included in specifications is made. The proposed scheme refers to uses, deliverables, Common Data

Environment (CDE), and quality control, as they are those that generate more confusion at the time of their establishment.

### 7.1. BIM Uses

The proposed uses are classified in compliance with the phase of the life cycle to which they belong, as well as according to the purpose to which they respond, in line with the classification of 'The Uses of BIM' document [43] of the University of Pennsylvania.

Table 1 shows a total of 22 uses that, in general, could be incorporated into the public sector tender contracts. However, their inclusion does not limit the owner from adding those specific uses of the life cycle stage to which the contract in question corresponds.

**Table 1.** Proposed BIM uses for inclusion in public sector tenders.

BIM Uses	Planning	Design	Construction	Operation and Maintenance	Purpose of BIM Use
Modeling of existing conditions		•	•	•	Gather
Design and 3D visualization	•	•	•	•	Generate
Obtaining 2D documentation	•	•	•	•	Analyze and communicate
Obtaining quantity take-offs	•	•	•	•	Analyze and communicate
Obtaining budget		•	•		Analyze and communicate
Generation of infographics and virtual tours	•	•	•	•	Analyze and communicate
3D coordination and collision management	•	•	•		Analyze
Simulations		•	•	•	Analyze
Energetic analysis		•		•	Analyze
Sustainability and environmental assessment		•	•		Analyze
Normative regulation		•			Analyze
Health and safety management			•		Analyze and realize
Centralized information	•	•	•	•	Communicate
Modeling of the executed work			•	•	Communicate
Inventorying			•	•	Communicate
Virtual and/or augmented reality		•	•	•	Communicate
Construction work monitoring (production and certification)			•		Realize
Maintenance and operation of the infrastructure				•	Realize
Work construction control			•		Realize
On-site layout			•		Realize
Logistics and stocks			•		Realize
Space management				•	Realize

The uses encompassed within the planning, design, and operation and maintenance phases have, as fundamental purposes, the analysis and communication of the existing

information or that which has been generated with respect to the asset that is the object of the contract, whether existing or to be executed. These purposes are also found in the uses assigned to the construction phase, although given its nature, others can be observed, such as implementation.

Several of the proposed uses are intrinsically related to each other. As an example, we can cite obtaining 2D documentation, obtaining quantity take-offs, and obtaining a budget, the object of which is to extract the traditional documentation of a project—necessary for the execution of the asset—from the model or models generated.

Uses such as the generation of infographics and virtual tours or virtual and/or augmented reality will allow an appreciation of the design of the asset in a very realistic way. In addition, they are complemented with the use of 3D coordination and clash detection, allowing early detection of possible interferences between infrastructure components.

### 7.2. BIM Deliverables

The deliverables proposed in this section have been extracted from the analyzed tenders, these being the most representative of the compilation.

Their designation has been harmonized, making use of the BIM guides and handbooks published at the national level in Spain, since a significant proportion of the tenders requested the same deliverables using different names. Then, they have been classified according to the life cycle phase specified in the contract (Table 2). Eight deliverables not included in the mentioned tenders have been incorporated to the proposal in order to properly adjust it to the needs of the sector.

Among the deliverables collected, there is part of the documentation traditionally requested in an execution project, such as plans, quantity take-offs, budget or work planning. However, there are also others specific to the use of BIM technology, such as the BIM Execution Plan—which should include the complete list of the deliverables required for the contract to which it belongs—the previous project, construction work, project and maintenance models, as well as the clash matrix. This last document checks all the collisions that may occur between the elements that are part of the project. Point clouds and base cartography are also part of BIM's deliverables, since they allow the analysis of the environment in which the asset will be located and its relationship with it by georeferencing the project model or models.

### 7.3. Common Data Environment (CDE)

Among the requirements for the Common Data Environment, the following are proposed:

1. Publication of files;
2. Ensuring interoperability through the use of open formats;
3. Search engine;
4. Exchange of information;
5. Storage of information;
6. Structuring based on a folder agreement and file encoding;
7. Activity control;
8. Data version control;
9. Management of user access to information (accessibility protocols).

Points such as file publishing and information search, exchange or storage are interrelated, and should be the minimum requirements to apply for a CDE that satisfy the general requirements of a project.

Regarding the use of open formats, this is one of the fundamental pillars of the use of BIM methodology, and it will allow the information generated to be viewed and/or edited, when applicable, by any of the agents involved in the process.



**Table 2.** Proposed BIM deliverables for inclusion in public sector tenders.

BIM Deliverables	Planning	Design	Construction	Operation and Maintenance
BIM Execution Plan	•	•	•	•
Point clouds	•	•	•	•
Base cartography		•	•	
Plans	•	•	•	
Quantity take-offs	•	•		
Budget	•	•		
Work planning			•	
Reports		•	•	
Simulations		•		
Infographics		•	•	•
Digital incident record (clash matrix)		•	•	•
Certification of works			•	
Existing infrastructure model	•	•	•	•
Alternatives study model	•	•		
Basic project model	•	•	•	•
Construction project model	•	•	•	•
Starting construction works model			•	
Construction monitoring model			•	
Executed work model			•	
Model for maintenance and operation			•	•
Health and safety model		•	•	
Federated model		•	•	•

On the other hand, the folder agreement and file coding may be established either by the tendered entity itself or by the bidder, based on its criteria and/or internal policy. However, it is recommended that they be aligned with the ISO 19650 standards, which indicate that an agreed and documented coding should support the collaborative production of information [44]. In this regard, it is worth highlighting the coding proposal established by buildingSMART Spain, in its ‘Document Nomenclature Manual when using BIM’. In it, a series of recommendations are made to name the different documents of a project. The inclusion of the following fields in the nomenclature should be stressed: project, creator, volume or system, level or location, type of document, discipline, number, description, status, and revision [45].

It is important, when proposing a CDE, to establish structures and agreements that allow information to be shared unambiguously. For this, it is recommended not only that the naming of the files be uniform and consistent, but also that all the parties involved make use of it, that it can be classified textually, and that it has a textual description. Additionally, the corresponding code of the selected classification system must be assigned to each object [46].

In any case, the aspects related to the CDE are included in the ISO 19650 standard, parts 1 and 2, of information management when using BIM. Therefore, it should be noted once again that the requirements presented here do not limit the owner from including those indicated in the aforementioned standard. It is also proposed to attend to the criteria

established in the 'Basic BIM Information Delivery Manual (MEI)', prepared by BIM Loket and adapted by the Planbim initiative [46].

#### 7.4. Quality Assurance

With reference to the quality assurance strategy presented in the specifications, the introduction of the following verifications is proposed:

- Geometric;
- Concerning the main BIM uses;
- Concerning the structure of IFC models and associated data;
- Relating to interoperability and version of IFC models;
- About nomenclature and coding of the data;
- About location (coordinates) of the models;
- About classification of elements;
- About the minimum information content;
- About coordination between models: clash detection.

Geometric checks should be carried out on the total number of discipline models included in the contract. This is the only way to verify the correct coordination between them and detect, when applicable, any existing inconsistencies. The geometric checks will also make it possible to verify compliance with the established tolerances.

Regarding the verification of the location, this should also be addressed in conjunction with the model coordination procedure, especially when a federated model has to be formed. It is important to pay attention to the units of the project, as well as the coordinate system used, verifying that the same criteria are applied in all models [47]. This avoids the generation of conflicts between elements.

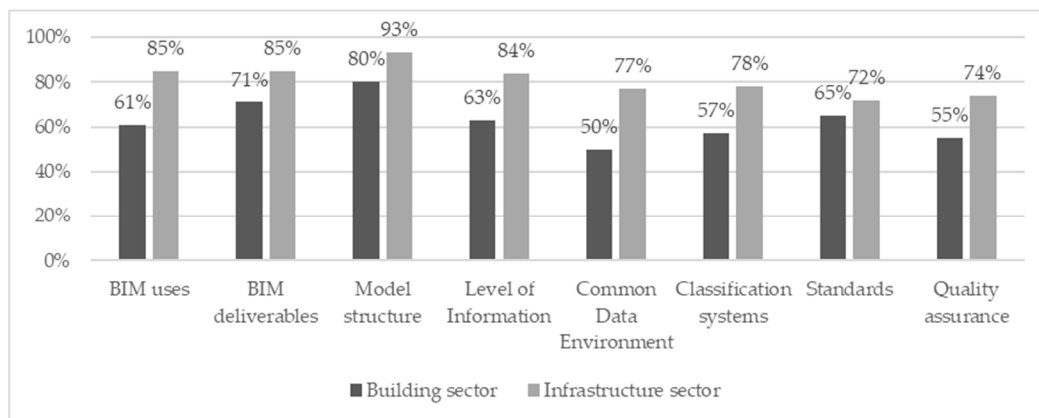
On the other hand, the verification of the interoperability and the version of the IFC models will guarantee that the information can be visualized outside the native programs used for its creation and that, in addition, there is no loss of data.

Likewise, since the BIM models of a project can collect a large amount of data, it is essential to check that the information contained in them is properly structured and encoded, and that it is that which is strictly necessary. The more information, the larger the file and the more resource consumption of the computer equipment used for editing and viewing.

## 8. Discussion

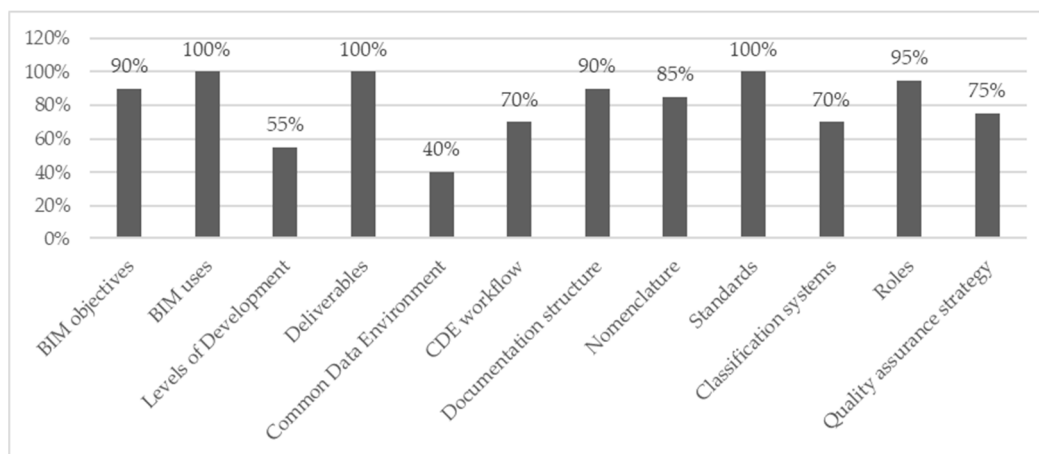
This section of the study illustrates the findings based on the quantitative analysis performed. The Spanish public tender sector has been examined in order to see the degree of implementation of BIM requirements in contracts. In the initial phase, a general analysis has been carried out, and a summary of the most requested requirements has been provided. The second phase has consisted of the compilation and analysis of representative tenders from both the infrastructure and building sectors. Finally, a proposal for general BIM requirements to be included in specifications is made.

According to the collected data, the investment and number of public tenders with BIM requirements in Spain have suffered a progressive increase during the period 2017–2020, this last year being the one with the highest investment (EUR 752 M). The volume of BIM tenders, from 2017 to October 2021 revealed that 56.0% of these were promoted by regional governments, compared to 20.3% by the state. These results demonstrate that, despite the stagnation of the initial state roadmap, the implementation of BIM methodology in the country is gaining momentum at an autonomic level. In fact, the region with the highest investment in this regard during 2020 has been Catalunya (EUR 287.92 M), where the obligation and use of BIM methodology in contracts are regulated by law. The findings also show that the infrastructure sector has a greater inclusion of BIM requirements in its tenders than the building sector (Figure 13).



**Figure 13.** Level of inclusion of BIM requirements in Spanish tenders by sectors, in the period of January 2020–August 2021.

The results obtained from the second phase of this study reveal that not all the requirements considered are requested with the same frequency. The total of the twenty selected tenders always determines the BIM uses, deliverables, and standards. Requirements such as BIM objectives, documentation structure, and roles are also usually defined. However, others like the Common Data Environment and Levels of Development are less popular, at 40% and 55% each (Figure 14).



**Figure 14.** Level of inclusion of BIM requirements in selected tenders.

With the information collected in this phase, a general proposal of BIM uses, deliverables, Common Data Environment, and quality assurance checks are presented. The first two types of requirements are classified according to the life cycle to which they belong—planning, design, construction and/or operation and maintenance. Furthermore, the uses are grouped into the purpose to which they respond, namely: gather, generate, analyze, communicate, and realize. Some of them fulfill more than one purpose, such as obtaining 2D documentation, generation of infographics and virtual tours, or health and safety management (Table 1). Regarding the deliverables, the BIM Execution Plan, simulations, alternative study models, clash matrices, or federated models, among others, have been included (Table 2). On the other hand, for the Common Data Environment, a total of nine requirements are considered, the same number as for the quality assurance strategy.

The proposal made could be used by public administrations at the time of drafting contracts, in order to prevent the publication of tenders with insufficient definition of requirements, which in turn could generate conflicts between the contracting and contracted parties. However, the research is based on one case study involving twenty tenders from

the Spanish public procurement sector. Consequently, the usefulness of the selection of requirements provided in this case study is therefore limited and may not be representative of the construction industry in other countries. In this way, its application by public entities outside Spain must be carefully studied. Further research can also be expanded to include the analysis of international public tenders, so that the proposal could be also applied at international level.

## 9. Conclusions

The BIM work methodology offers multiple advantages within the AECO sector. First, it allows the digital construction of an asset (building or infrastructure) with the precise geometry. This facilitates the detection of errors, conflicts or loss of information from the early stages of the life cycle. BIM also makes it possible to estimate quantity take-offs and budgets quite accurately, which translates into lower costs during the execution and maintenance stages. Likewise, it facilitates communication between the agents participating in the processes.

The procurement process is one of the most challenging in the life cycle of a project, due in large part to the competitiveness between the different contractors, who seek to provide the best offer to achieve the award of the contract. The use of the methodology can increase this competitiveness. However, its use could also lead to possible legal problems, since the structure of traditional contracts is not prepared for the collaborative approach that BIM offers. The existence of ambiguities, the inadequate designation of roles and responsibilities, and the lack of precision regarding the ownership of the models can lead to conflict and disputes between the parties. It is therefore necessary to adapt the structure of the contracts so that they include all these issues, as well as a data management policy that guarantees the security of the information generated.

The development of BIM is quite advanced in places such as the Netherlands, China or the United Kingdom. In Spain, for its part, a roadmap was prepared with different milestones for its implementation at the national level. However, the changes of government that have taken place have led to a stagnation of the initial proposal. Despite everything, various regions of the country have made great progress in relation to its incorporation, such as Catalunya or Euskadi.

The entry into force of Law 9/2017, on Public Sector Contracts, was an important milestone in the country as far as BIM is concerned, since it is the first legislative document at the national level that makes mention of this technology. However, this does not regulate the mandatory nature of its incorporation into public sector tenders, although it is true that the administrations could demand its use based on the principles of administrative discretion, public interest, and non-discrimination.

Spain has a BIM Public Tender Observatory, known as CBIM, which aims to analyze tenders from the national public sector, as well as identify and compile those that include requirements associated with technology. The pertinent review of the information collected by this entity indicates that in 2020, there was the highest volume, both in investment and in the number of tenders with BIM requirements registered to date, with an increase of 230% compared to 2017. Tenders with a lack of a sufficient definition of BIM requirements are detected, possibly due to a lack of references from the entities that published them.

This article collects the analysis of twenty tenders of the Spanish public sector, in order to identify the rate of implementation of the methodology. With the data obtained, a proposal for BIM requirements has been made that could be used as a reference for many of the tenders. The proposal includes the definition of different areas of BIM requirements: uses, deliverables, a Common Data Environment, and quality assurance. The proposal made is not intended to be a standardization or a norm, but rather a recommendation that serves as the basis for the contracting entities for the drafting of the tenders, so that they are as complete and consistent as possible. In any case, what is established here would not exempt the owner from including those other requirements that may be necessary depending on the nature of the asset.

**Author Contributions:** Conceptualization, N.M.-D. and J.Á.A.; methodology, A.P.-G. and N.M.-D.; formal analysis, A.P.-G. and N.M.-D.; investigation, A.P.-G., N.M.-D., and J.Á.A.; writing—original draft preparation, A.P.-G. and N.M.-D.; writing—review and editing, A.P.-G., N.M.-D., and J.Á.A.; visualization, supervision, N.M.-D. and J.Á.A.; project administration, N.M.-D.; funding acquisition, N.M.-D. and J.Á.A. All authors have read and agreed to the published version of the manuscript.

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**Conflicts of Interest:** The authors declare no conflict of interest.

## Appendix A

**BIM Objectives:** They are understood to be the purpose or goal that the client—in this case, the tendered entity—intends to achieve with the implementation of the BIM methodology. The objectives can respond to several factors, so their definition is not an individual task, but a consensual task [25].

**BIM uses:** Activity based on a BIM model, among all those that are necessary for the complete execution of a process, which adds value to its development and allows the obtainment of any of the previously established objectives [27]. The classification system of BIM uses proposed in the document ‘The Uses of BIM’ [43], from the University of Pennsylvania, categorizes them, mainly, by the purpose and objective of the use in question.

**Levels of Development (LOD):** It is defined as the agreed degree to which a BIM model must be developed based on the contracted work phase [48]. One of the most common references is that of BIMForum, which defines for six levels of information (100/200/300/350/400/500), the degree of geometric detail, as well as the attributes necessary for each element [25]. The publication of the EN 17412-1: 2020 European standard—disseminated in Spain under the name UNE-EN 17412-1: 2021—brings with it a new concept, the Level of Information Need (LOIN). This is defined as the framework that determines the scope and granularity of the information to be exchanged. It is described using the concepts of geometric information, alphanumeric information, and documentation [49]. Given that the publication of this standard is recent, the tenders analyzed include the term LOD and not LOIN, therefore, in later sections of this document, reference is made to the first.

**BIM deliverables:** Specific documentation of the use of the BIM methodology generated during the course of the contracts [40].

**Common Data Environment (CDE):** It is defined as the only agreed source of information for any project or asset to collect, manage, and disseminate each container of information, always through a managed process [25,50].

**CDE workflow:** Used to support the production, management, sharing, and exchange of all information collaboratively during the development and operation phases, describing the processes that will be used during these [50].

**Structure of the documentation and file nomenclature:** It is understood as the organizational data system adopted by the entity that developed it, so that the agents who participate in the process can feed it and maintain it in an orderly and efficient way [25]. In



turn, the file nomenclature is the assignment of a standardized and common coding of the documentation generated for all the intervening agents [42,51].

BIM standards: Document that determines provisions to treat, structure, and define information in projects that are developed in a company and helps to normalize work processes in the BIM environment [52].

Classification systems: A way of organizing construction elements that categorizes concepts and facilitates their grouping based on some specific attributes or properties [25].

Roles: Function that is exercised during the work processes in BIM environments and implies training and qualification for its realization [40].

Quality assurance strategy of the models: Process consisting of the implementation of a quality system based on parametric strategies and massive information processing, which guarantees the usability of the data captured throughout the process and the improvement of the quality of the models [40].

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