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Use of BIM as a Support for Tendering of Facility Management Services

Daniel Macek

Department of Economic and Management in Civil Engineering, Faculty of Civil Engineering, Czech Technical University, 16629 Prague, Czech Republic; daniel.macek@fsv.cvut.cz; Tel.: +420-224-354-529

Abstract: Basic 3D models of real buildings are mainly used in the design phase, when they serve as a visualization of future projects or as a basis for the creation of project documentation. However, the possibilities of Building Information Modeling are much wider. The paper presents the options available during the tendering for the company's support service providers within the framework of Building Information Modeling (BIM). The principle is based on defining the necessary content of the Building Information Modeling, which would enable a smooth transition between the implementation and operational phases. At the end of the implementation phase, the model should contain information that could be used for the needs of the selection process for facility management service providers, which, unlike normal construction production, have many of their own specificities, but are necessary for the operation of the facility. This information must be entered into the model during the entire construction process in the form of defined parameters, a defined format and the location of these parameters. The purpose of the Building Information Modeling should primarily be the optimization of costs during the entire life cycle of the construction project, as well as better and clearer availability of information and facilitation of cooperation between individual participating entities. Therefore, the prerequisite for using the Building Information Modeling as the main basis for tendering is its high-quality processing, which places high demands on all participants in the investment project.

Keywords: Building Information Modeling; documents for tender; facility management; tendering of facility management services

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1. Introduction

Facility management (FM) is defined in the ISO 41000 standard as "an organizational function that integrates people, places and processes in a common environment to improve the quality of people and the productivity of the core business". In layman's terms, it is a field that deals with the management of the already mentioned support activities and thus enables the company to concentrate on its main activity [1,2].

The paper focuses on the issue of tendering for facility management services in Building Information Modeling (BIM).

The main difference in the selection process for services is the emphasis placed on customer feedback. In the case of selecting a supplier or construction contractor, the most advantageous supplier is generally sought, i.e., the supplier with the lowest offered price (subject to compliance with all quality, technical and business conditions of the contracting authority) or the supplier with the most economically advantageous offer [3,4]. Therefore, service providers cannot be selected primarily on the basis of price, but the quality of the services offered also plays a large role. In practice, even though today the already mentioned Act 134/2016 Coll. has been in force for several years, the issue of providing support services is still insufficiently described and specified. As a result, most large FM providers do not even enter public tenders for support services, and a large number of inconsistent contracts are concluded at unrealistically low prices with small to medium-sized companies [5]. However, these companies often do not have very high "know-how", so the quality of the services provided is lower. The new law makes it possible to issue a high-quality tender, but it also requires equally well-developed documents, which, however, require more time for preparation and higher costs, which few public entities are willing to undertake. Unlike the Czech Republic, in developed countries, the public sector is the domain of large FM providers [6–8].

Tendering for FM service providers in a building that has been in operation for some time is usually issued due to the expiry of the current supplier's contract, or in case of dissatisfaction with the fulfillment of contractual conditions [9]. In such a case, all the necessary information about the financial demands of individual areas of building management is already available from previous years (mostly entered into some internal company system) and the course of such a selection process is not the content of this paper.

In the case of new buildings, the tender process starts approximately six months to a year before the construction is completed. Functioning facility management is a prerequisite for the first employees to move in. Ideally, at this point, the BIM should contain all the necessary information for issuing a quality and fair tender [10–12]. Of course, there is information regarding the sum of the areas of the rooms, including their surfaces, or the sum of the areas of the tiles, on the basis of which the offer of cleaning work is drawn up. Furthermore, at least the number and type of technical equipment for the operation of regular maintenance, revisions and other related technologies and equipment should be known, to which service and emergency services, building maintenance or winter and summer maintenance of external areas and greenery are linked [13,14]. The more such information can be obtained directly from the model, the easier the work of the contracting authority is, as it allows him to compile procurement documentation in such detail that he would otherwise not be able to achieve, or it would be too time-consuming. An example of such parameters can be, for example, information about the regular maintenance of a specific device (i.e., maintenance period, possibly time and financial demands, etc.), which the manufacturer of the given device would enter directly into the model and the client would only "pull" and use. If such information was not entered in the model and the client wanted to get a better idea of the price he can expect for the maintenance of such equipment, he would have to find it himself and have it priced [15–17]. That is why it is important to involve the FM team in all phases of the construction project and, in particular, to draw up a high-quality BIM implementation plan that specifies the details of the information that enters the model at each phase of the project and thus prepare the basis not only for the operational phase, but also for the tender process itself [18–20]. It is said that it is cheapest for an investor to obtain data at the moment of its creation and, if it is already calculated in advance, that a selection procedure will take place, which will take place in any case. The whole process can be simplified with suitable input data [21,22].

The information from the BIM model must also contain the necessary data related to the actual operation of the building. Current building models contain this information, but I have not come across a study or a practical application where the BIM model would directly generate documents for tendering for support activities within the framework of FM, which need to be implemented even before the construction itself is completed. In order to generate the necessary information, the BIM model must contain relevant information that is embedded in a suitable data structure. The paper focuses on specifying these requirements. It was necessary to find the parameters that will be entered into the model and to choose a suitable classification structure.

2. Literature Review

Since there are not many academic articles devoted to BIM support for the selection process for facility management providers, the chapter is divided into two parts: an investigation of the issue of tenders in facility management and an investigation of the support of BIM for facility management.

2.1. Tenders for Facilities Management Providers

A number of submissions were processed for the selection of a facility management provider. The articles deal with issues in various stages of selecting a provider of support activities. The most common problem solved is the determination of evaluation criteria for the evaluation of the selection procedure. Models are described that combine various factors, such as cost, quality, risk, credibility and supplier capabilities, into a single criterion that can be used for supplier selection and evaluation decisions. This system allows users to enter various criteria that are important for a given project and then compares and evaluates suppliers based on these criteria [23].

Another area is the provision of facility management services through the Public-Private Partnership (PPP) program, which has increased in recent years. The long-term success of this partnership depends primarily on the selection of the most suitable private partner. However, while selecting the best FM service providers under this scheme, a problem was discovered with the unavailability of the evaluation criteria. Preliminary research shows that evaluation criteria are essential elements of the FM procurement process, but little attention is paid to this topic. Evaluation criteria are essential in selecting the most qualified FM service providers, especially for complex projects such as PPP. Thus, the objective of this research is to identify the evaluation criteria for FM through the PPP scheme. In this article, an in-depth literature review was conducted. The focus of the revision was connected to the evaluation criteria of FM service providers in the PPP scheme. This paper identified four criteria to be considered, namely client requirements, external environment/factors, project characteristics and financial benefits. The result of this paper can be used as a theoretical basis for the development of an FM procurement framework for a PPP scheme [24].

The field of data structure for FM is also related to the selection process. Studies examine the impact of different organizational models on the management of ancillary processes in the facility management industry and try to suggest which one is best in terms of strategic and operational advantages and disadvantages. The analysis made it possible to identify a total of 11 organizational models, which are the result of five different strategic approaches. A comprehensive classification framework of strategies and organizational models is proposed based on two dimensions: the organizational role of the ancillary process manager (called the “facility manager”) and the typology of ancillary process/service providers. The framework makes it possible to identify and explain the main advantages and disadvantages of each strategy and to highlight how a company should coherently choose an organizational model, based on (a) specialization/complexity of secondary processes, (b) focus on core processes, (c) its inclination towards outsourcing know-how and (d) the desired level of autonomy in managing secondary processes [25].

It is necessary to connect the data for FM with the information system. Big Data Analytics (BDA) is available, which collects and stores the data using specific data software [Construction Operations Building Information Exchange [COBie], Integrated Worksite Management Systems [IWMS], Computer Aided Facility Management (CAFM), etc.], and it can play a vital role in improving the performance management system in the facility management industry. It defines the components of big data and explores the benefits of BDA in any business through an extensive literature review and a pilot case study in the United Arab Emirates [26].

A cross-section of the development of the provision of support activities is captured in a study based on literature reviews, case studies and more than 25 years of personal in the public sector. The contribution maintains an international focus on FM development, with a particular focus on developments in Norway and the Nordic countries. The triangle of knowledge development and its integration of education, research and practice is used as the basic theoretical framework. The choice of FM in practice, whether to provide services fully or partially with internal resources or to enter into agreements with external suppliers, is an important strategic decision regarding the choice of purchasing strategy for a company or organization. This decision is not necessarily about outsourcing or in-house, but rather about strategically sourcing and managing the services needed. A total of 25 years of research has shown that there is a lack of simple solutions and answers to questions about in-house or outsourced FM services. To find a good solution, it is necessary to understand the content of FM services with respect to quality and efficiency and to understand the interaction between FM, main activities and users [27].

2.2. BIM and Support for Facility Management

In recent years, Facility Management (FM) processes have become more and more digitized, which requires an effective integration of BIM and FM. The adoption of BIM in many countries, such as the UK, Italy and Brazil, has been publicly supported. In general, adoption has been focused on design and implementation of the structure, with little public action effort to implement FM. The absence of an integrated approach to BIM-FM implementation has led to numerous tailor-made implementation approaches that mimic the private sector and hinder the exchange of knowledge. Therefore, there is a need to evaluate and consolidate knowledge about BIM-FM for public organizations. However, the difference between BIM-FM for public and private organizations is uneven. BIM-FM research for public organizations is still limited and lacks standardization [28].

There is growing awareness and use of building information modeling (BIM) for construction project delivery and operation of facilities. Evidence of successful project delivery with BIM abounds, and large facility owners are increasingly adopting BIM project delivery. BIM has shown increased efficiency in integrating the people, processes and technology involved in facilities management. Concurrently, owners are turning toward leveraging the sophisticated technology and processes afforded by BIM to derive more value from their facilities. This involves navigating complex organizational and technical issues, leading to a shift from traditional practices. However, there are still uncertainties regarding the legal aspects of applying BIM to facilities management because the domain is still in an incipient stage of maturity both in academic research and practice [29].

In some applications, such as facility management, it is not always convenient to work with the full details of a building's BIM model. Generalization techniques have been proposed to meet the model generalization requirements. Techniques deal with generalization of geometry and generalization of descriptive information. The generalization is also developed in relation to the definition of the level of development [30].

BIM makes it possible to transform the information necessary for the entire construction process into a language that computers can understand. In architecture, BIM is actively used throughout the construction life cycle, while the Construction Operations Building information exchange (COBie) standard was developed to provide information generated in the design and construction phase to the maintenance phase based on a BIM environment. COBie is designed to exchange information about a building between the implementation and operational phases of its life cycle. This accurately describes what COBie really is, that is, a standard that defines the data structure for the exchange of information about the construction, especially between its contractor and the future operator. This standard was created for the purpose that the data generated during the design and implementation of the building could be effectively used for its subsequent management [31].

The BIM methodology is intended and directed for the management of the life cycle of the building's numerous advantages. However, use during the operational phase remains limited. Despite the leadership of decision makers in supporting the use of BIM at all stages of the building life cycle, the most significant barriers remain related to cost (both for BIM software/hardware and training). Perhaps as a result, the lack of expertise and ignorance of BIM-related technologies is one of the most inhibiting obstacles that also requires maximum attention. It can be concluded that additional resources need to be committed by industry stakeholders to help overcome barriers and enable wider adoption of BIM for FM. The increased application of BIM for FM will have positive implications for the future of the FM industry and the digital future of the built environment, which is a national strategy.

The results are expected to identify the most fundamental barriers to technology-enabled change in FM practices [32].

3. Materials and Methods

From the literature review, it is clear that in the operational phase of the objects' life cycle, the use of the BIM methodology has great reserves, and its potential is not being used. This fact is directly related to the field of facility management. This work focuses on the area of BIM support during tenders for facility management providers. Specifically, it concerns the preparation of documents for the tender procedure. It means the creation of a tender budget which will serve as a control budget for the client, but, at the same time, this budget (without the listed prices) will be used to create a price offer from the providers.

The method focuses on new buildings where no operating data is yet available. The goal is to create a bid budget for FM at the pre-construction stage, using the BIM methodology, which is inherently designed for this, but remains virtually unused.

The basis of the principle is to have information about technical devices that describe operational data on individual steps of maintenance and revisions of the device, including a description of individual activities, contained in the BIM model from the very beginning, when a specific device is inserted into the BIM model. This data should either be directly in the digital template of the respective device. Otherwise, the information should be added from the operating documentation from the manufacturer. The data structure of the BIM model must be appropriately defined for the correct assignment of information. At the same time, the device is classified in the internationally recognized classification system for building products, materials, premises, building parts, etc. However, for the purposes and needs of facility management, the classification needs to be paired with the activities that are defined within the FM support activities. Subsequently, it is then possible to use information from BIM for the needs of FM, in this case specifically for the creation of documents for tendering for FM providers.

First of all, it is necessary to describe the details of the BIM model, the data of which will be the basis for such a tender. As mentioned in the previous paragraph, the tender process begins several months before the construction is completed and the model of the actual construction is handed over [33–35]. It is therefore currently easier to work with the updated model for the execution of the building. At this stage, it is already determined what devices will be placed in the building, their parameters proposed by the designer and (with a few exceptions) a specific manufacturer is also selected [31,32,36].

The BIM Execution Plan (BEP) sets general requirements that do not necessarily stem from the needs of facility management, but are common to all participants in the construction process and describe a uniform way of entering data and their form. Examples of such requirements include [37,38]:

- The location of the model and its orientation, i.e., determination of the starting point of the central model and the geographical and height system, which is usually determined in the basic model (most often the architectural building part) and which is taken over by all developers of professional parts;
- Basic units that are uniform for all workers who will work with the model. These are mainly length units (mm), area units (m^2), volume units (m^3), load (kN, kN/m, kN/m^2, etc.) and weight (kg);
- Nomenclature, i.e., dividing the model into sub-parts and marking them, marking rooms, floors, elements, etc.

This requires a level of detail that defines how detailed such a model is. It is a combination of graphical and non-graphical information.

The information needed for facility management must be contained in the BIM model in a suitable classification structure. The OmniClass classification structure was chosen for this purpose [39,40]. A classification system contains numbered titles of classified work results or design procedures that are primarily used to organize specifications, manuals and detailed project information, as well as to create a design specification record. It provides a standardized way of storing and retrieving lists, section names and numbers to organize design, product and activity data requirements. This facilitates communication between architects, budgeters, contractors and suppliers.

Information from BIM needs to be assigned to individual support activities. The ČSN EN 15221-4 standard "Taxonomy, classification and structures in facility management" [41] was chosen as support for defining the supporting activities that will be part of the selection process. This part specifies and partly regulates the breakdown of facility services. It introduces code designations for categories of facility services and describes individual services in terms of their content, scope, costs and tools. This is not a complete overview of all services, but the overview provided shows the core areas and the most important services in each category.

The preventive maintenance items and their cycles are then described in detail for each item. The solution procedure can be seen in Figure 1.

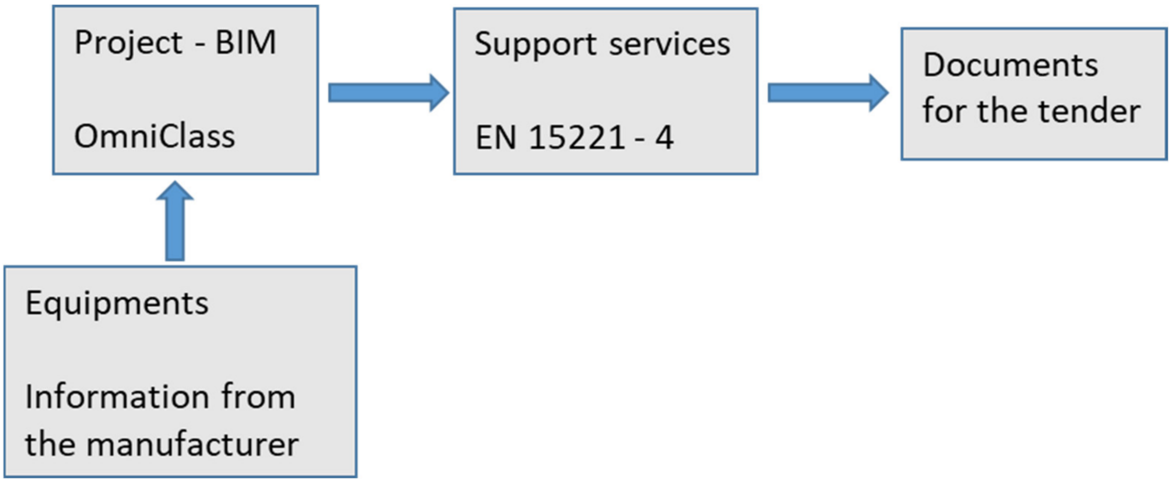

Figure 1. Diagram of the solution process. Source: author.

4. The Main Problems of Public Contracts for FM Services

4.1. Continuous Quality

In the case of tendering for a specific product, it is assumed that its properties and parameters will not change, and thus the functionality and quality of this product can be determined unambiguously. In the case of services, where there is a requirement to improve the quality of services over time (PDCA) directly and according to the ISO and EN standards, certain developments are expected [42–44]. If the service does not improve over time and becomes stagnant, it does not satisfy the needs of the customers and, as a last resort, it would be necessary to re-tender and re-specify new requirements. Therefore, it is important to use Key Performance Indicators (KPIs) to describe where the service will develop further within the tender process [45]. In the event that the provider does not have much experience in participating in this type of tender, the process of collecting data from the client can be very laborious and can take up to several months [46]. The initially set KPIs should be gradually adjusted to correspond with increasing quality and, at the same time, must be subject to a contractual agreement between the client and the provider [29,47].

4.2. Different Ideas about Quality

This point points to a contradiction between practice and the Public Procurement Act. According to the Public Procurement Act, the conditions of the tender procedure are set in advance and any later adjustment is not possible [48]. This means that, if both contracting parties agree on certain evaluation conditions, these conditions cannot be changed later in the public sector, as this would conflict with the original tender conditions. A particular example of such a situation is the different perception of the quality of the service provided.

The client establishes certain conditions with the provider and, after the commissioning, he discovers that his employees perceive the quality of work carried out differently and that the original assignment needs to be modified. For this reason, the so-called "mobilization phase" in the private sector is introduced during the first few months of the contractual relationship, when the client and the provider supplement and modify the service as required by the actual operation. The public sector has no such introduction phase [49,50].

4.3. Economically Effective Offer

In general, an economically efficient offer can be defined as an offer with the best price–quality ratio. In the case of deliveries and construction works, other parameters can be specified quite precisely, and therefore it may happen that the investor chooses the offer according to a criterion other than the lowest price (for example, the shortest construction time or the most suitable qualification prerequisites) [51]. In the case of a tender for services, the situation is more complicated. Firstly, service quality cannot be assessed only objectively according to predetermined parameters, but the so-called "soft" subjective parameters, dependent on the human factor, also play a large role. Secondly, it is also necessary to take into account the cost parameter during the life cycle, when individual devices will need to be serviced at various intervals, etc. Therefore, in the case of services, the best evaluation criterion is the lowest price, which, with rare exceptions, is perceived as the most economically efficient [52].

If a situation arises where the customer is no longer satisfied with the quality of the service provided and has to repeat the selection process, it is usually the case that the newly offered prices will always be higher than those on the basis of which the previous contract was concluded (influence of inflation, increase in the minimum wage, etc.) [53–55]. However, there is a risk that the winning price will still be so low that it will not allow the new provider to offer better quality services than its predecessor. If a provider who has been performing the activity thus far enters the newly announced tender process, he already has a certain idea of the costs and resources he will have to spend and will therefore set the price based on this. However, other suppliers do not have an overview of what quality parameters the client values and thus estimate the price based on experience, ideally as low as possible. The original provider often does not win the newly subscribed tender in this way, and the new supplier must once again go through the process of adaptation to the established system. In any case, the client probably did not improve the situation for himself because, if the new supplier was chosen on the basis of the lowest price, he cannot expect much improvement. The ideal solution for the company would be to keep the original provider and, at regular intervals, analyze the current situation with him, possibly agreeing on a price adjustment. Calling out a new tender (if the existing provider does not win) is usually never advantageous for the company. This model is directly excluded by the public procurement law, even though it is a common practice in the private sector [56–58].

5. Data Required for FM

In the model, it is necessary to have the information necessary from the point of view of facility management (for example, operating and technical sheets necessary for regular maintenance) [59]. This information is then inserted into the model as a hyperlink that refers to a specific PDF file provided by the manufacturer of the given device, where all actions that must be performed on the device during its lifetime are described verbally.

Ideally, this data should be converted into a format that could be further processed by computer, thus introducing some automation into the entire data entry system required for FM. The first step is therefore to determine which parameters are crucial for the operation and maintenance of the given equipment and which of these parameters would subsequently be appropriate to use as a basis for the selection procedure.

In the next step, it should then be possible to determine in what form to request it from the manufacturer. The main idea could thus be a certain standardization of the form of the data provided, which would be stated directly in the procurement documentation (and would be based on the BEP), and the responsibility for providing it would thus be transferred directly to the manufacturer. For example, this would take place during the selection process of the supplier of the mentioned air-conditioning unit, in addition to the classic design and technical parameters (size, material, power consumption, efficiency, etc.). The model would also include the FM parameters provided by the manufacturer, i.e., the mentioned revisions and maintenance. Currently, manufacturers are already able to deliver their devices equipped with Quick Respond Code (QR) codes or Radio Frequency Identification (RFID) chips, which can then be easily connected to the Computer Aided Facility Management (CAFM) system database and thus gain access to all data about the given device that is available in the system [60,61]. In this way, instead of attaching an operating and technical sheet, the manufacturer could bypass the contractor's work and immediately provide the information needed for maintenance and revisions using such a data structure that could be directly entered for a specific device in the form of FM parameters. Ideally, information about how demanding /expensive such future maintenance will be would also be included.

The question, therefore, remains, what information should be requested from the manufacturer and in what form. The basic criteria that will help to determine how high regular maintenance costs should be for the chosen equipment could be [62]:

- Frequency of regular maintenance;
- Time requirement.

The frequency of preventive maintenance depends to a certain extent on the environment in which the device will operate. For example, a fan that will be installed in a production hall where it will be very dusty will need to be cleaned and maintained more often than a fan located in an administrative building. The manufacturer should therefore distinguish between these conditions and determine the frequency for at least two representative types of environments. The time required is directly related to the estimated number of hours the craftsman will spend inspecting the equipment. Here, the manufacturer should take into account both a regular inspection, such as once every three months, when it suffices to open the device, check the cleanliness and overall condition, and annual thorough maintenance, when the device will need to be disassembled, lubricated, have its filters replaced, etc. The financial burden of these two criteria is to a certain extent already included in both points, but there is also a need to take into account, for example, whether the previously mentioned device filter needs to be replaced once a year and how much a new spare part will cost, or whether it will be necessary to increase or replace operating fluids, etc. The frequency of preventive maintenance depends to some extent on the environment in which the equipment will be operated.

The process of determining such parameters and their possible interpretations will be illustrated using the example of mechanical air-conditioning equipment from the BIM model, which was provided for the purposes of this work. On the basis of the available data on the number and type of equipment and the operating sheets corresponding to them, the following Table 1 was compiled:

The Table 1 shows that there are six Adiabatic Air Humidifiers in the building that require regular maintenance once every three months. Mostly, however, the maintenance involves a visual inspection or possible replacement of one of the components. It always depends on the situation. There is only one resistive air humidifier in the building and, thanks to the use of demineralized water, the frequency of maintenance is minimized. In any case, the manufacturer recommends regular maintenance, at least once a year, which will be sufficient in this case. To demineralize the water entering the humidifiers, the device system "Water Treatment for Humidifiers" is used, where the manufacturer recommends checking all components once a day. Furthermore, there are 16 air-conditioning units in the building, which require more regular maintenance every six months to a year, and once every three months a general inspection of the individual components is sufficient. Another item is the fans of the air handling units (here 5 pcs), where the manufacturer recommends a regular check once every three months and once a year to a year, in addition to more thorough maintenance and cleaning. The last category is the other fans. There are a total of 27 of them, from two different manufacturers, in the building, but the operation sheets for all of them stated that they are maintenance-free, the only maintenance consisting of cleaning the impeller as needed (at least once a year).

Table 1. Preventive maintenance requirements for selected equipment. Source: author.

Number	Type of Device	Component	Preventive Maintenance Activities	Frequency
6	Adiabatic air humidifier	Pump	Checking/replacing water filters	3 M
			Checking the oil level	1 M
			Oil change	3 M
			Inspection/replacement of seals and valves	3 M
		Frame/distribution system	Visual inspection (clogged nozzles, solenoid valves, accessories, drain and water, drip eliminator)	3 M
1	Resistance humidifier		Cleaning and descaling of all parts that come into contact with water (filling valve, pipe for filling/draining water, drain pump, heating elements, filling tank, filter and scale collector, level sensor)	12 M
			Replacing the seal in the developing container	12 M
16	Assembled air conditioning unit (Supply + Exhaust)	Shell	Cleaning	3 M
			Checking the inspection door seal	12 M
		Filter	Checking the pressure loss and the need to replace the filter	3 M
		Carbon filter	General inspection	3 M
			Replacement of cylinder, carbon or cartridge as required	6 M
		Valve	Function and seal check. If necessary, replace the gasket	3 M
		Rotary recuperator	General inspection	3 M
			Seal inspection	3 M
			Cleaning the rotor	6 M
			Check the running monitoring device and blow through	12 M
		Plate recuperator	General inspection	3 M
			Damper function check	3 M
			Cleaning the recuperator chamber	6 M
			Cleaning of the recuperator chamber, drain valve and cladding	12 M
		Cooling unit, radiator	Follow instructions and local regulations	3 M
		Air heater, air cooler, water exchanger, electric air heating	General inspection	3 M
			Cleaning the rib body	6 M
			Cleaning of the rib body, drain pans and sheathing	12 M

Table 1. *Cont.*

Number	Type of Device	Component	Preventive Maintenance Activities	Frequency
		Humidifier	Check casing, humidifier insert, drip separator, water filter, tub, spray pipe, water flow, constant flow valve	3 M
		Ventilator	General inspection	3 M
			Belt tension check	6 M
			Checking the belt tension, cleaning the impeller, cover and casing. Checking the condition of the bearings and lubricating the bearings, if required, in SKF SNA 5(0) TAV lubricators	12 M
		Fan for installation in an overpressure chamber	General inspection	6 M
			Cleaning the impeller, cover and casing. Checking the condition of the bearings and lubricating the bearings, if required, in SKF SNA 5(0) TAV lubricators	12 M
		Muffler	Cleaning as needed	3 M
5	Air conditioning unit (Exhaust)	Ventilator	General inspection	3 M
			Belt tension check	6 M
			Checking the belt tension, cleaning the impeller, cover and casing. Checking the condition of the bearings and lubricating the bearings, if required, in SKF SNA 5(0) TAV lubricators	12 M
1	Water treatment plant for humidifiers, flow rate 870 L/h	Mechanical pre-filter	Check the tightness of the water connections, remove any leaks	1 D
			Check the filter cartridge for clogging, remove any deposits by splitting the filter	1 D
		Duplex softening filter	Check the tightness of the water connections, remove any leaks	1 D
			Checking the condition of the regeneration salt in the salt container	1 D
			Checking the quality of the outlet water	1 D
		Reverse osmosis	Check the tightness of the water connections, remove any leaks	1 D
			Checking the quality of the outlet water	1 D
			Checking the water pressure at the reverse osmosis inlet	1 D
			Checking the input mechanical filters	1 M
		Subsidiary electrical switchboard	Checking the condition of the cabling	1 D
		Treated water tank	Check the tightness of the water connections, remove any leaks	1 D
4	Axial fan with adjustable blades		No maintenance, just clean the impeller as needed	12 M
1	Diagonal fan for circular duct		No maintenance, just clean the impeller as needed	12 M

Table 1. *Cont.*

Number	Type of Device	Component	Preventive Maintenance Activities	Frequency
4	Noise-insulated radial fan in a square duct with an EC motor		No maintenance, just clean the impeller as needed	12 M
6	Metal radial fan for circular duct		No maintenance, just clean the impeller as needed	12 M
6	Metal radial fan for circular duct with EC motor		No maintenance, just clean the impeller as needed	12 M
5	Radial fan for square duct		No maintenance, just clean the impeller as needed	12 M
1	Radial fan for square duct with EC motor		No maintenance, just clean the impeller as needed	12 M

All the above information was taken and interpreted on the basis of the operation sheet for the specific equipment that was used in the building. In general, it can be said that if such a device is included in a certain category, then the same FM activities (regular maintenance and revision) will always be performed on it, regardless of the manufacturer. An example of such inclusion could be the classification code that each device should be assigned in the modeling program. For the purposes of this work, the OmniClass system will be used, where the individual devices listed in Table 1 could be classified in the manner listed in Table 2.

Table 2. Classification codes of individual devices according to OmniClass. Source: authors according to [39,63,64].

Device	OmniClass	
	Classification Code	Title
Ventilator	22-23 34 00	HVAC Fans
Adiabatic air humidifier	22-23 84 13 13	Wetted-Element Humidifiers
Resistance humidifier	22-23 84 13 26	Steam Humidifiers
Water treatment plant for humidifiers	22-23 25 23	Water Treatment for Humidification Steam System Feedwater
Assembled air conditioning unit (supply + exhaust)	22-23 73 13	Modular Indoor Central-Station Air-Handling Units
HVAC unit (exhaust)	22-23 82 23	Unit Ventilators

6. Design of a Data Entry System into the BIM Model

It is necessary to design such a system for entering parameters so that they are understandable not only for humans, but also for a computer to process them. The theory is based on the assumption that the devices are classified into the respective categories (see Table 2) and for each category there can be such a list of FM activities that will be common to all the devices included in it.

The first step is to assign corresponding FM activities to each category. The most detailed list of FM activities that can be carried out within individual areas of facility management is given in the standard ČSN EN 15221-4 "Taxonomy, classification and structures in facility management". The standard contains several hundred different activities that can be performed within individual categories. The list has a tree-like structure and is always divided into categories and subcategories, as well as devices and their corresponding FM activities. The basic distribution is shown in Table 3.

Table 3. Basic breakdown of FM activities according to the ČSN EN 15221-4 standard. Source: authors according to [65,66].

1—Space and infrastructure
1.1—Accommodation and space services 1.2—Workplace 1.3—Technical infrastructure 1.4—Cleaning 1.5—Other space and infrastructure
2—People and organizations
2.1—Health, Safety and Security 2.2—Care of users of objects 2.3—ICT 2.4—Logistics 2.5—Other people and organizations

Those activities that are closest to the manufacturer's requirements were selected from the standard and were compiled in a form that visually corresponded to the structure of the itemized budget used for construction work. In this form, it is possible to continue working with the "budget". It is possible to determine the price for one FM operation of one piece of selected equipment and, after multiplying by the number of equipment and taking into account the annual period, it is possible to obtain the total cost of maintaining such equipment for a year. It thus shows how much the total maintenance of all mechanical equipment for air conditioning will cost. Such information offers a comparative value for the contracting authority, through which he can gain an idea of what prices he can expect from the participants in the tendering process.

At the same time, such a budget is a suitable basis for awarding a tender. As in the case of an itemized budget for construction works, here, too, each FM activity would contain details determining precisely what each activity entails and which aspects are not included in it. This would ensure the same conditions for all participants, as it is precisely specified here what activities are expected from the future provider. The contracting authority thus sends the participants a "blind budget", i.e., only a list of works and quantities (similar to a statement of dimensions) and they will price it.

Based on the previous information, it would therefore be possible to enter information about the regular maintenance of a given category of equipment based on a code referring to the relevant list of FM activities. In the case of used mechanical devices, such a classification would look like Table 4.

Table 4. Assigning a classification code to a preventive maintenance activity code. Source: author.

Classification According to OmniClass		**The Area of FM Activities from the Norm**	
Code	**Description**	**Code**	**Description**
22-23 34 00 22-23 84 13	HVAC Fans Humidifiers	1.3.3.1 1.3.3.4	Air handling equipment Humidifiers
22-23 84 13 13	Wetted-Element Humidifiers	1.3.3.4.1	Water humidifiers
22-23 84 13 26	Steam Humidifiers	1.3.3.4.3	Steam humidifiers with a steam generator
22-23 25 23	Water Treatment for Humidification Steam System Feedwater	1.3.3.23	Water treatment plant for humidifiers
22-23 73 13	Modular Indoor Central-Station Air-Handling Units	1.3.3.22	Assembled air handling unit (exhaust + supply)
22-23 82 23	Unit Ventilators	1.3.3.22	Assembled air handling unit (exhaust)

7. Extracting Data from the BIM Model

There are two ways to enter or retrieve data using the BIM model. The first is the one-time input or export of information that was originally, for example, in paper form, and it is necessary to manually enter it into the system. Such data are usually created during the modeling of individual elements or are assigned to them later. The second option is to synchronize the database of the modeling program (Revit, ArchiCAD) with the database of the CAFM system.

Data for technical management, building maintenance and cleaning can be obtained from the model. The first area that can be efficiently extracted from the model is surfaces. The facility manager is usually interested in data on the areas of the rooms in connection with their capacity, as well as the surfaces of the rooms (carpet, tiles, antistatic screeds, etc.), areas of window fillings, areas of tiling and others [38,67]. The second group includes information about individual devices that are subject to technical building management, i.e., their number, type, location, etc.

7.1. IFC and CoBIE Export

The Industry Foundation Classes (IFC) format is suitable as an interchange format for coordinating between BIM models from different sources [68,69]. In a simplified way, it should allow you to export data created in, for example, Revit and access it in ArchiCAD, where it should be possible to work with it in the same way as in the original program. For simpler objects, such a process works relatively well without problems, but in the case of more extensive constructions, some data may no longer be displayed as the user would imagine. In any case, it is primarily a data structure that can be accessed and managed in a text or table editor after export. Revit offers several different IFC formats that can be used for export, and each of these templates can be further modified according to the user's requirements to create a basis for the tender process. Autodesk has released the "Revit IFC manual" which describes IFC file types, their structure, object classes, object attributes, detail levels, mapping between IFC and Revit object types and more.

For the needs of facility management, it is more appropriate to use the straight Construction Operations Building Information Exchange (COBie) format, which maintains the same structure, but directly selects/filters data important for FM [70]. Data can be transferred within IFC and, therefore, can directly connect to a digital 3D model, but more often it consists of an ordinary XLS table structured exactly according to a defined template. Based on such a template, the user determines what information he needs from the model and how it will be sorted. Autodesk provides a free plug-in for Revit (the so-called "COBie Extension for Autodesk Revit") [71], which provides assistance to the user in the preparation of the model incl. COBie data and allows export directly to British Standard format.

7.2. Export Report to Excel

Exporting to a text file is a basic function of every modeling program. Revit makes it possible to create reports directly within the working environment, which can be inserted, for example, as room tables into drawings, printed as attachments or exported and further worked on in another table or text editor. Any number of columns mapping the used parameters of individual elements can be displayed on all reports. All elements can be merged, sorted and filtered.

Conversely, the import of tabular data (for example from Excel) is a function that Revit does not support in its basic version. There is no direct connection between Revit and Excel yet, so such an import cannot be performed, and all changes made in the table editor must be entered manually in the modeling program. However, there are several plug-in/add-in applications that should allow you to connect an Excel Spreadsheet so that you can work with the uploaded data in Revit in the same way as if it were an internally created schedule. Examples of such add-ons include CAD studio, Ideate BIMLink, Exceler8 or the Imaginit Utilities plug-in. Another option for advanced users is to program a macro that will enable the export and import of Excel data or to create a custom script in the Dynamo programming tool. The author of this work is of the opinion that such a bidirectional connection would definitely make working with the program easier in certain respects. For example, if the numbering of rooms or the names of departments are changed at the investor's request, the designer must make each such change for each room separately. In this regard, the table editor offers more formatting options and is clearer and faster for editing a larger volume of data.

7.3. Export to CAFM System

Archibus, as an example of a specific CAFM system, provides a plug-in application for Revit (and AutoCAD), which enables two-way synchronization between the databases of both software programs. Archibus is an application that can be viewed using a web browser, thus viewing the database. The database itself can be managed using either the SQL language in the relevant user environment (depending on the database used, most often the SQL Developer is used for Oracle or Microsoft SQL management studio is used for Microsoft SQL Server) or using the SmartClient administrator program [72]. The last-mentioned program allows you to view individual tables and edit data across the entire database and, at the same time, connects the Revit database with the Archibus database using the aforementioned plug-in.

8. Discussion

8.1. Life Cycle Costs

The data that is obtained for the purposes of the tender process can also be used to optimize the life cycle costs of the entire building [73].

In the design phase, the designer of the given part determines the parameters of all the devices that will be located in the building. Based on them, a tender is issued for the supplier of such devices. At this stage, the purchase price and costs of operation and eventual disposal of such equipment must be taken into account. The contracting authority thus puts itself in a position where it has to assess whether it will be more advantageous for it to choose a device with a higher price, but lower operation costs, or a cheaper device with higher costs for its maintenance and repairs [74].

In many cases, the investor is mainly interested in the initial costs, but the author of this thesis is of the opinion that a higher initial investment is usually more advantageous in the long run. If a cheaper device needs to be replaced twice in a five-year time frame, while its more expensive alternative will still work without a problem, then such an investment will definitely pay off for the client [75].

8.2. Advantages and Disadvantages of BIM for FM

8.2.1. Advantages [13,56,76]

1. Clearer management of the building space—the BIM model will allow access to information about the use of the building faster and the information provided is more accurate;
2. More effective maintenance—in the BIM model, up-to-date information about products and related assets is maintained. Access to more accurate information faster is again the main advantage, as it enables more qualified decision-making;
3. Efficient use of energy—the use of the BIM model enables the comparison of different solutions and their energy needs. The available information supports various types of traffic optimizations as well as suggestions for improvements. In this way, the impact on the environment can be better influenced.
4. More efficient implementation of maintenance work (renovation) and changes to completed buildings (reconstruction)—the updated BIM model is, again, a source of more accurate information about the current form of the building and allows the necessary time to be used for processing different variants of solutions instead of finding primary information;

5. Better management of the life cycle of the construction—this point hides the willingness to evaluate the costs of the entire life cycle against mere investment costs. The initial higher acquisition costs can thus translate into much lower operating costs for the entire building;
6. More efficient data transfer between the BIM model and the CAFM system.

8.2.2. Disadvantages [13,56,76]

- Investment in new software;
- Employee training;
- Diversity software;
- Problems when the BIM model does not have data in the required structure;
- Risks when transferring data between systems.

8.3. Summary and Development

I have not found a scholarly article that addresses the link between BIM and the procurement of support activities within FM, which suggests a gap in addressing this issue. In practice, specific values (e.g., dimensions, number of elements) are exported from the BIM model for tenders, but the data no longer contain information about individual maintenance activities. The main reason is the absence of information in the BIM model, when, in the phase before the completion of the project implementation, the BIM model does not contain the necessary information about operational matters. Data on operational matters appear only after the BIM model is converted to CAFM, where this information is additionally supplemented. The solution is not only to enter operational information in the CAFM system, but into the BIM model during the earlier phase of project preparation. Information regarding the individual steps of preventive maintenance and its cycles should be inserted into the model with the insertion of the relevant technical elements. The source of the information is the manufacturer of the technical element, who supplies it as part of the operational documentation.

Correctly setting up the data structure of the BIM model and entering information at the right stage of the project will yield the results expected from BIM. So far, the issue is still developing and the biggest room for improvement is providing information for the operational phase of projects.

9. Conclusions

The paper showed the use of the BIM model as a support for the selection process for facility management providers. The basic principle is based on adding the necessary information at the right time to the BIM model. For the activities of the operational phase of the building, which fall under the facility management department, information in the BIM model is often missing or added only at later stages of the project. Much of the information about the operation is added only in CAFM systems, which draw data from the BIM model. However, most operational information is dependent on the design phase, and this information should be automatically included in the BIM model before the building is operational. That is, CAFM systems would import most of the information from the BIM model, saving work and time (money).

In this particular case, a procedure is proposed to obtain materials for tendering for FM providers in the form of budget items that will be exported from the BIM model. First of all, it is necessary to have information about work activities and their cycles contained in the BIM model but not to enter them in the operational phase in the CAFM system, which should take this information from the BIM model. Furthermore, it is a matter of correctly connecting the data structures so that the resulting outputs correspond to the structure of the supporting activities within FM. Here, the connection of the OmniClass classification structure with the connection to the classification of support activities defined in the standard ČSN EN 15221-4 Facility management—Part 4: Taxonomy, classification and structures in facility management was used. This principle is applicable internationally.

As regards the determination of prices for individual activities for the tenderer's control budget, national price systems must be used here. Even here, however, it is possible to use automatic calculations, when the price items are connected via an identification code to the price system. This not dealt with in the article, but it is an incentive for further development of the given topic.

The purpose of the BIM model should primarily be the optimization of costs during the entire life cycle of the construction project, as well as providing better and clearer information and facilitation of cooperation between individual participating entities. Therefore, the prerequisite for using the BIM model as the main basis for tendering is its high-quality processing, which places high demands on all participants in the investment project. If the BIM model contains all the parameters needed for facility management at the end of the implementation phase, and the provider of such parameters is determined in advance, as well as their form, this model can be used for the purposes of tendering for FM service providers.

An important factor is the definition and description of the essential parameters of the FM, required for tendering the building management provider. Another factor is to establish information about the time required and periodicity of individual activities. The tender process was set in the period towards the end of the implementation phase, i.e., 6 months to a year before the handover of the building [77]. Based on the collected information, it can be stated that the tendering process for construction works and supplies is very methodical and adheres to well-established (and sometimes outdated) procedures, while the field of services is always controlled by a specific entity. The model, which will serve as a basis for the selection process, should contain relevant information needed for facility management. These should ideally be established in cooperation with the facility manager, who will be present during all phases of the project and the implementation of the investment. The paper described several systems for extracting data from the BIM model, all depending on the quality and form of the entered information. These methods have been described with respect to current software capabilities. The author would conclude the whole issue by summarizing that the Czech environment is ready for the use of the BIM model, at least from a technical point of view, and the biggest obstacle lies in the need to set uniform standards, break established procedures and gather information.

The paper could be further developed by specifying the parameters that could be inserted into the model. In the text, it was proposed to insert the parameters of regular maintenance in the form of a code, based on the list of FM activities specified in the standard. This list of FM activities was currently the only sufficiently detailed database that could be used for this purpose. There is an opportunity to further expand this database and thereby create a basis for entering parameters applicable for tender purposes in the form of a unified coding system.

The described process of digitization of the construction industry is a relevant topic, and it is possible to state that development in this direction is almost inevitable. In order for the entire system to function, it is first necessary to define processes, i.e., specify the activities and procedures to be automated. Today's society still relies primarily on humans. For example, a construction budget accountant must know all the necessary technological procedures for the correct valuation of the construction, the continuity of the individual stages and have a practical overview of how the construction will proceed. Some of this information is described in technical sheets or other manuals, but most of it is "in the head" of such a person. Such an accountant, with many years of experience, becomes an invaluable employee. However, computer algorithms do not work in the same way as the brain of such a budget manager. They need to have everything precisely defined and logically arranged. The aforementioned need for standardization is also related to this. A precisely defined data structure enables collaboration and data sharing not only within a single project, but also provides room for comparison and improvement in the entire construction industry.

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