A Smart Management System for Operation and Maintenance of Facilities

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Abstract. Facilities maintenance management plays a crucial role in the construction industry because it increases facility efficiency, maintains facilities, increases their lifespan, and assists in continuous supervision of facility efficiency. Traditional methods used in facility maintenance management lead to an increase in the time and cost of maintenance and a lack of effective maintenance of the facility. In addition to an inability to ensure that the required maintenance is carried out due to the absence of monitoring maintenance work, thus reducing the facility's efficiency. The overall goal of this paper is to improve the efficiency of facility maintenance, which reduces maintenance time and cost and increases the long-term span of the facility. In addition to providing continuous monitoring and verification of maintenance work. This paper presents building information modeling (BIM) technology in facility maintenance management. This BIM model of the facility is used to know the geometric and non-geometric information for any element in the facility and schedule the periodic maintenance of all elements in the facility. Creating a BIM model for the operating room that contains all the information for all the elements inside it and scheduling periodic maintenance for all elements in the hospital.

Keywords: Building Information Modelling (BIM), facility maintenance Management System (FMMS), periodic maintenance.

1. INTRODUCTION

Building Information Modeling (BIM) is rapidly transforming the way facilities are managed. Traditionally, facility management relied on paper-based documentation and siloed data, leading to inefficiencies and challenges in maintenance practices. BIM, on the other hand, offers a centralized, data-rich approach that can significantly improve facility maintenance operations.
BIM has revolutionized facility maintenance management by providing comprehensive asset information and enabling informed decisions about maintenance tasks, resource allocation, and space utilization. Also improving maintenance planning and scheduling by allowing managers to visualize

equipment locations, identify potential issues, optimize maintenance routes, reduce downtime, and save costs. BIM also promotes better communication and collaboration between facility managers, maintenance teams, and stakeholders, reducing errors and simplifying communication.

Xinghua Gao, et al. [1] discussed the use of BIM in facility operation and maintenance and the challenges of applying BIM in facility operation and maintenance, such as understanding the principles of operation and maintenance and the return on investment of applying this technology. Also, research on its application is still in its early stages.

Ibrahim Mutawa, et al. [2] discussed how to use BIM in facility maintenance, all technical information related to facility maintenance must be provided in the BIM model to transform from (Building Information Modeling) to (Building Knowledge Modeling).

Marjan Sadeghi, et al. [3] discussed that in order to use the BIM model in facility maintenance, it must have the developmental characteristics and specifications that the owner needs, and the importance of use-based identification of model requirements to avoid delivering incomplete or unnecessary data.

Antonio Salzano, et al. [4] discussed to use BIM model in facility maintenance on an existing building, it must be provided with a building condition assessment (BCA) to enhance maintenance efficiency, quality, and speed. The case studies focus on historical and culturally valuable buildings, emphasizing the importance of digitalization for sustainable maintenance and conservation strategies.

Zul-Atfi Ismail, [5] discussed how to use a BIM model in industrial building system (IBS) maintenance. A BIM model should be integrated with design and construction information, diagnosis, and defect risk assessment in industrial building systems (IBS). The methodology used interviews and prototyping of the system development life cycle to address maintenance management problems. The prototype system integrates BIM technology to provide better defect analysis, expert systems to support design defect control efficiency, and a rule-based expert system to provide recommendations for maintenance and repair of IBS components.

Although previous studies provided valuable information about the use of BIM in facility maintenance management, they avoided discussing and studying the information discussed in this research, which is:

- Produce a BIM model that includes all geometric and non-geometric information for each element in the facility used in facility maintenance management.
- Provided a digital presentation and simulation of the facility.
- Scheduling periodic maintenance appointments, determining element location, maintenance times, and identifying maintenance requirements.

2. OBJECTIVES OF THIS PAPER ARE AS FOLLOWS

A Building Information Model (BIM) of the facility is created, which contains all geometric and non-geometric characteristics of each element in the facility. This allows facility managers or technicians responsible for maintenance to:

- Quick and easy access to all the necessary information for each element in the facility.
- This model does not require specialists to handle it, but it allows all those responsible for managing and maintaining the facility to use it and easily access information related to each element of the facility.
- It allows the facility manager to make the right decision by providing all information about each element in the facility.
- Providing a simulation model of the facility, which helps in decision-making.
- It works to provide information about the facility in electronic form instead of traditional methods of making printed plates for the facility that are easy to lose or damage over time, and thus this information about the facility will be lost.

- Saving time and effort spent searching for information about the facility and thus reducing costs in managing and maintaining the facility.
- Scheduling periodic maintenance for all elements of the facility, which helps maintenance managers follow up and monitor planned maintenance work and thus helps improve the maintenance efficiency of the facility.

3. METHODOLOGY

- Create a model of the facility using the Revit program.
- Provide each element in the facility with geometric and non-geometric information, such as element name, element type, element dimensions, element specifications, and produced company.
- Integration between the model of the facility and all information about each element in the facility to produce a BIM model using facility maintenance management.
- Scheduling the periodic maintenance for all elements in the facility for a year by determining the element, its location, and the date of the maintenance.

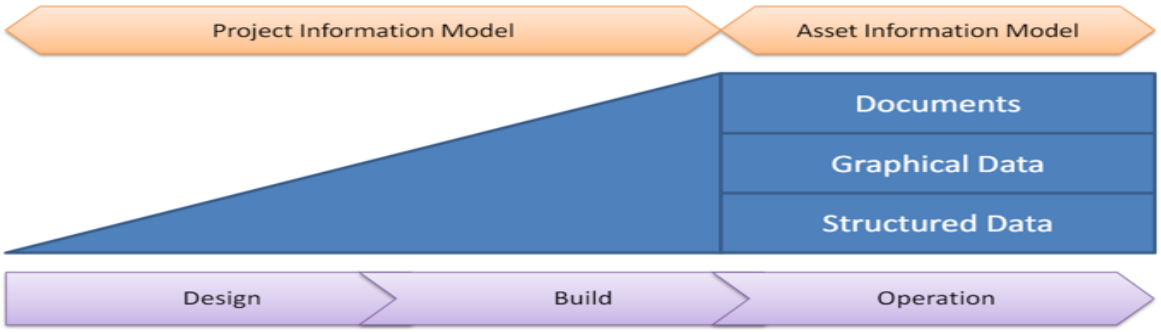

Figure 1. Project information delivery.

4. CASE STUDY

4.1. Description of Case Study

This study was applied to a hospital building located in Cairo, Egypt, consisting of six floors of different sizes, as **Table 1**.

Figure 2. Elevation of the hospital.

Table 1. Areas of Hospital.

Level	Area (m2)
Basement	3878
Ground floor	4100
First floor	3782
Typical floor	2870

4.2. BIM technology was applied in this hospital, which is as follows:

1. Make Building Information Modeling (BIM Model) of an operating room inside a hospital as an example. This model includes all the geometric and non-geometric characteristics of all the elements inside this room.
2. Scheduling periodic maintenance appointments for the hospital.

It will be explained how this technology was applied in the management and maintenance of the facility as follows:

4.2.1. Create Building Information Modeling (BIM model) containing all the geometric and non-geometric information of the facility.

A BIM model of the facility is created that contains all the geometric and non-geometric characteristics of each element in the facility. This model allows facility managers or technicians responsible for maintenance to offer quick and easy access to all necessary information for each element in the facility, eliminating the need for specialists. Aiding facility managers in making informed decisions by providing comprehensive information about each element. The model also provides a simulation model for decision-making. It uses electronic information instead of traditional printed plates, which can be easily lost or damaged over time. This saves time and effort spent searching for facility information, thereby reducing costs associated with managing and maintaining the facility. Overall, the facility management model is a valuable tool for efficient facility management.

This technology was applied in a hospital operating room by creating a BIM model of the operating room on the Revit program, and all information about each element inside this room was provided as follows:

- The walls inside the operating room include the following information: name of the item, type of paint, dimensions, technical specifications, and name of the producing company, as shown in **Figure 3.**
- The floors inside the operating room, and the information includes the following: name of the item, type of floor, area, technical specifications, and name of the producing company, as explored in **Figure 4.**
- Doors inside the operating room, and the information includes the following: item name, door type, dimensions, technical specifications, and the name of the producing company, as explored in **Figure 5.**
- The lighting lamp inside the operating room includes the following information: name of the item, type of lighting, technical specifications, and name of the producing company, as shown in **Figure 6.**

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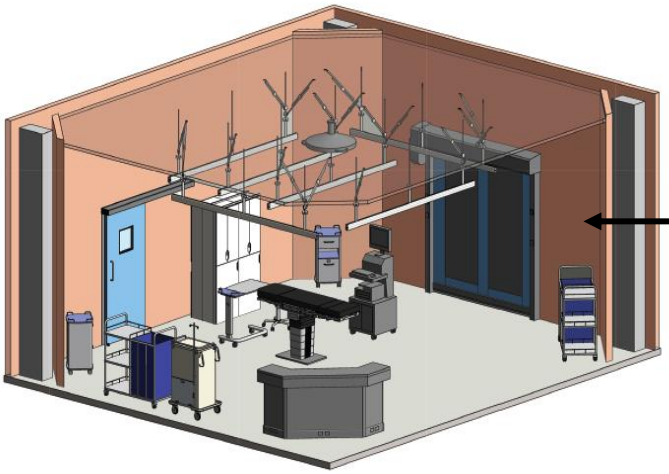
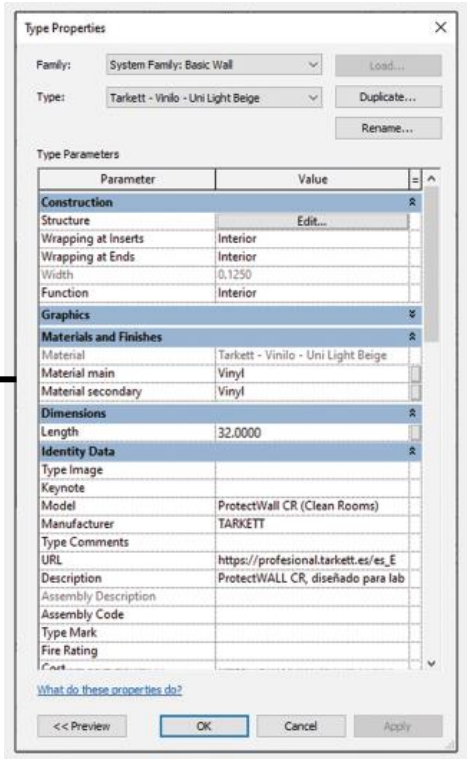
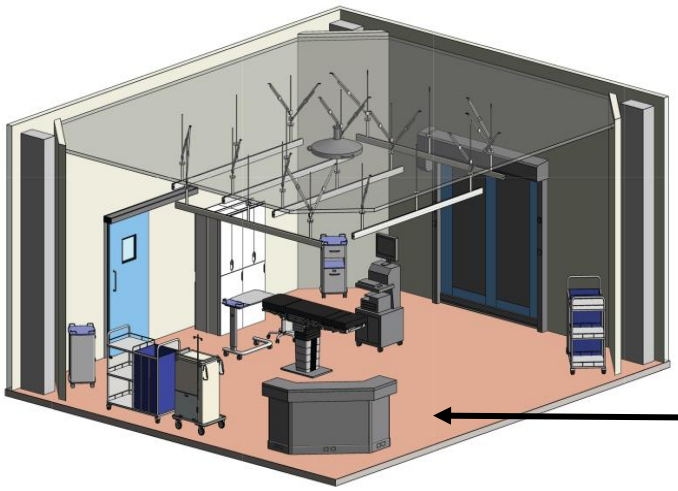


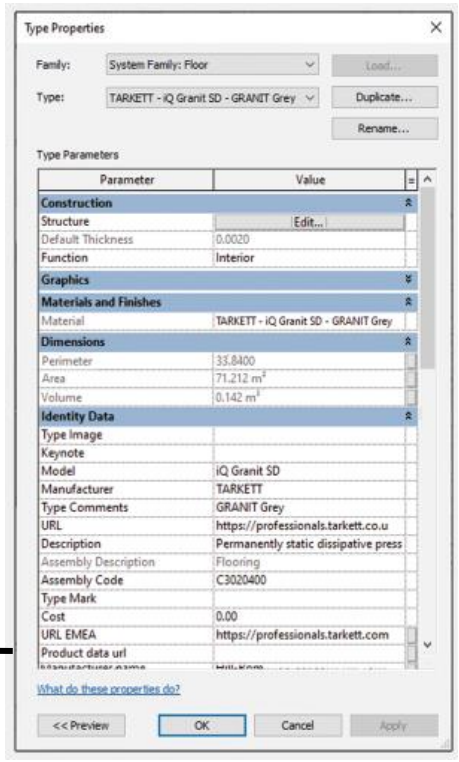


a\ Operating room model.

b\ Specifications of the walls inside of the operating room.

Figure 3. Walls Information.

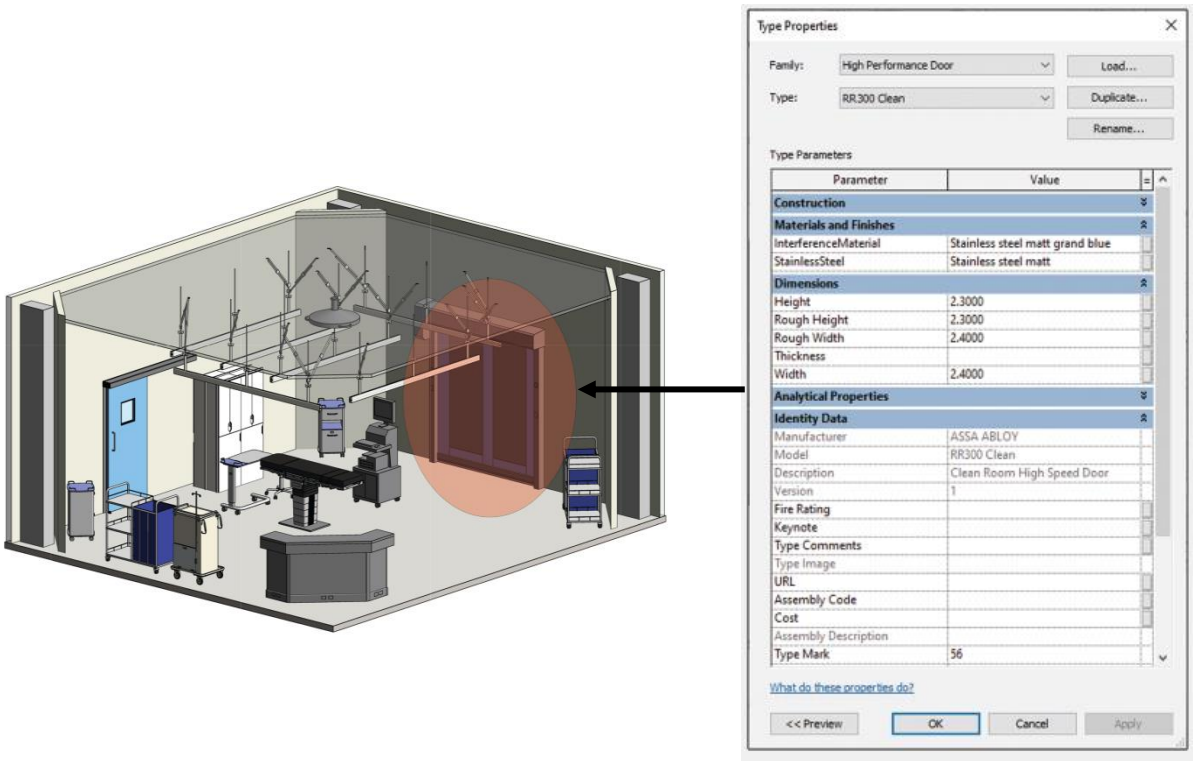




a\ Operating room model.

b\ Specifications of the floor inside of the operating room.

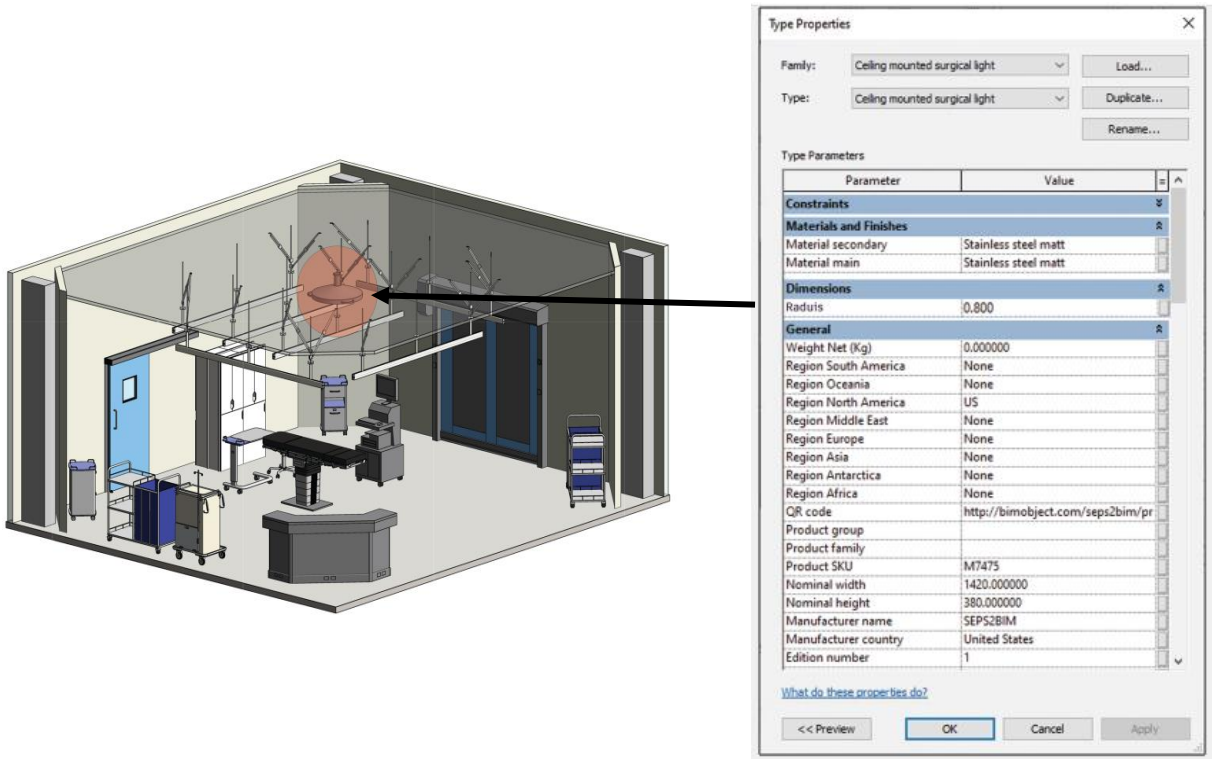
Figure 4. Floor Information.



a\ Operating room model.

b\ Specifications of the door inside of the operating room.

Figure 5. Door Information.



a\ Operating room model.

b\ Specifications of the surgical light inside of the operating room.

Figure 6. Surgical light Information.

4.2.2. Scheduling appointments for periodic maintenance of the facilities.

By creating tables using the Excel program, schedules for periodic maintenance are made for all elements and all specialties present in the facility, and their dates are determined. It is possible to create maintenance schedules for the entire facility for a full year, so that during this year periodic maintenance is carried out for all elements and specialties present in the facility, including through these tables, a maintenance date is determined for each element that requires periodic maintenance. It is possible that there are elements that require monthly maintenance, other elements that require quarterly maintenance, and elements that require annual maintenance, and this is determined according to the specifications and special codes for each element within the facility. It is possible to create schedules for periodic maintenance for each specialty separately. For example, we create schedules for periodic maintenance for the electrical and electronics system specialty alone, and it is the responsibility of the electrical technicians to perform this maintenance on the specified dates for each electrical element in the facility, as well as the specialty of HVAC System, Plumbing System, Fire Fighting System, and Electromechanical Equipment.

Maintenance schedules related to each specialty are the responsibility of technicians specialized in this specialty to implement the maintenance included in the schedules and implement on time. These planned schedules for periodic maintenance for each specialty and each element in the facility help the maintenance officials in the facility on maintenance dates. This gives the opportunity to be fully prepared to maintain all elements in the facility beforehand and to prepare for this maintenance by providing the spare parts necessary to carry out this maintenance and providing all the necessary needs for them at short notice. This saves time and money and improves the maintenance efficiency of the facility. In addition, these planned schedules for periodic maintenance for all specialties are available to facility managers in order to know the necessary maintenance dates for all elements in the facility and all specialties and to follow up and monitor their implementation on their planned dates and their success.

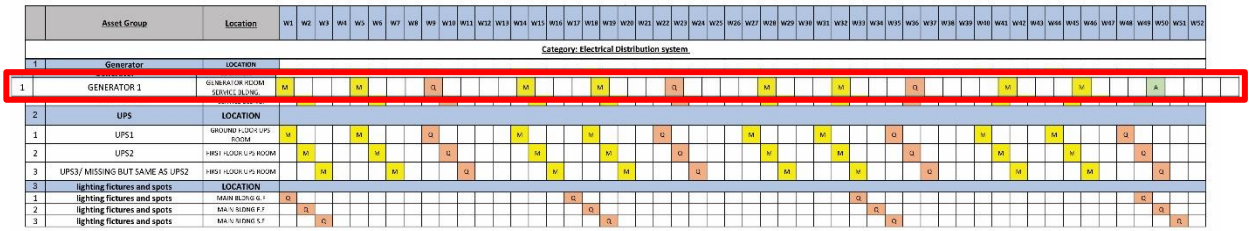
This was applied to the hospital by creating periodic maintenance schedules for each specialty in the facility for a full year by dividing the year into 52 weeks and writing down all the elements that need periodic maintenance for each specialty, specifying the maintenance date for each element in each specialty in the facility, and specifying each maintenance. Is it monthly maintenance, symbolized by the letter (**M**) and in yellow, is it quarterly maintenance, symbolized by the letter (**Q**) and in orange, or is it annual maintenance, symbolized by the letter (**A**) and in green. This was determined based on the technical specifications and codes for each element in the facility.

The following was also specified in these tables:

- Type of specialization (the electrical and electronics system, HVAC System, Plumbing System, Fire Fighting System or Electromechanical Equipment)
- Items within this specialty that require periodic.
- The location of each item in the facility.
- Maintenance schedule, specifying (monthly, quarterly, or annual maintenance).

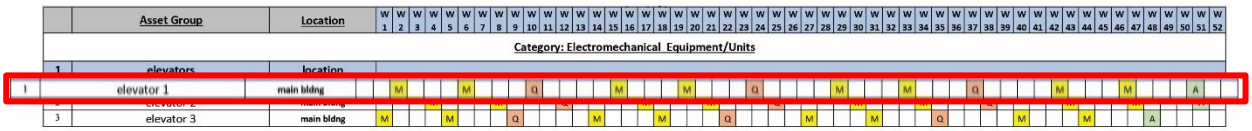
For Example, No. 1 is the schedule for periodic maintenance of the electrical system for one year, including all elements within this specialty, such as (generator 1) the specific location in (the generator room) and the specific need for (monthly) periodic maintenance based on the technical specifications of the generator. It was determined that the monthly maintenance period is for a whole year, as explained in **Table 2**.

Table 2. Example No. 1 Electrical Distribution system for a year.



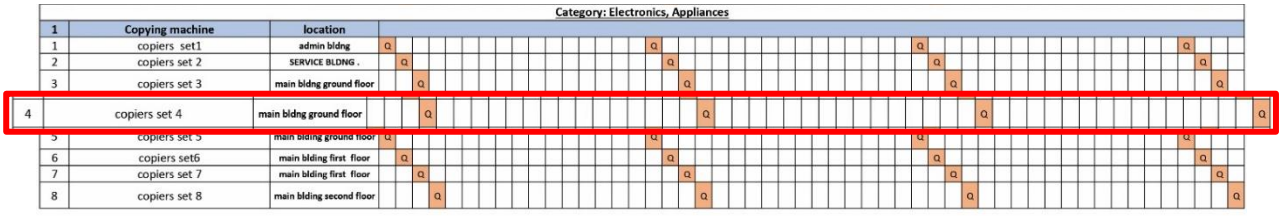
For Example, No. 2 is the schedule for periodic maintenance of the electromechanical system for one year, including all elements within this specialty, such as (elevator 1) the specific location in (main building) and the specific need for (monthly) periodic maintenance based on the technical specifications of the elevator. It was determined that the monthly maintenance period is for a whole year, as explained in **Table 3**.

Table 3. Example No. 2 Electromechanical Equipment/Units for a year.



For Example, No. 3 is the schedule for periodic maintenance of the electronics, and appliances system for one year, including all elements within this specialty, such as (copying machine: copiers set 4) the specific location in (main building ground floor) and the specific need for (quarterly) periodic maintenance based on the technical specifications of the copying machine. It was determined that the quarterly maintenance period is for a whole year, as explained in **Table 4.**

Table 4. Example No. 3 Electronics, Appliances for a year.



5. CONCLUSIONS

Facilities maintenance management refers to the strategic planning, organization, and execution of activities aimed at maintaining and optimizing the performance of physical assets within a facility. It involves a systematic approach to managing maintenance tasks, including preventive maintenance, corrective repairs, inspections, asset management, resource allocation, and documentation. FMM ensures that buildings, equipment, systems, and infrastructure are kept in optimal condition to support smooth operations. In traditional facilities management, problems are addressed as they arise. This led

to interruptions and disruptions of operations, which led to more time being spent maintaining the facility and, thus, a higher cost of maintaining the facility. Budgeting is a challenge for traditional financial management due to its fragmented approach and the potential for unexpected expenses. While traditional facilities management may not always provide the strategic insights needed for long-term planning, all of this negatively impacts the efficiency of facility maintenance and, thus, the efficiency of facility operation. The purpose of this paper is to use the Building Information Modeling (BIM) in facility maintenance management. This is a tool that provides facility managers and maintenance technicians with a comprehensive view of each element in the facility. This model provides quick and easy access to information about each element, eliminating the need for specialists. It aids in making informed decisions by providing comprehensive information about each element. It also offers a simulation model for decision-making. The BIM is provided electronically, eliminating the need for printed plates, which can be easily lost or damaged over time. This saves time and effort in searching for information, reducing costs in management and maintenance. Additionally, BIM schedules periodic maintenance for all elements, enabling maintenance managers to monitor and improve the facility's maintenance efficiency. Overall, BIM is a valuable tool for facility management and maintenance. The methodology followed in this paper is produced A BIM model uses it in facility maintenance by providing geometric and non-geometric information about each element in the facility, eliminating the need for specialists. This model aids in informed decision-making and provides a simulation model for decision-making. It uses electronic information instead of traditional printed plates, saving time and effort and reducing costs associated with facility management. Prepare Periodic maintenance schedules are created for all elements and specialties in a facility, with dates determined. These schedules can be created for a year, covering monthly, quarterly, and annual maintenance. Maintenance dates are determined based on specifications and codes for each element. Technicians in each specialty are responsible for implementing maintenance schedules on time, and helping facility officials plan and prepare for maintenance. These schedules help facility managers know necessary maintenance dates and monitor their success. This saves time and money, improves maintenance efficiency, and ensures all elements are prepared for future maintenance.

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