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Building Information Modelling (BIM) for Facility Management (FM): Industry Survey of Building Assets

Brandi Williams[1], Brian Haines[2], Kathy Roper[1], & Eunhwa Yang[1§]

[1]School of Building Construction, College of Design, Georgia Institute of Technology, 280 Ferst Dr. Atlanta, GA 30332
[2]FM:Systems, 2301 Sugar Bush Road, Suite 500, Raleigh, NC 27612

[§]Corresponding author, eunhwa.yang@design.gatech.edu, 1-404-894-7103

ABSTRACT

The purpose of this paper is to discover the current methods that facility managers use to manage and track assets and identify a set of attributes for Building Information Modelling (BIM) that can improve the efficiency of the current facility management (FM) practice. A survey of over 100 facility management professionals addressed demographics such as industry sector, number of buildings managed, and use of industry standards or internally developed guidelines for data management. This information is correlated with their current asset management strategies to identify minimum sets of attributes that may be used for an FM-specific BIM. In addition, the survey asked the FM professionals their opinion on the importance of specific asset attributes and data management information that could be included in a BIM for FM. The findings of this paper indicate that there is a consensus on basic information (asset type, unique identification, manufacturer, model number, serial number) needed for asset management, and that there is no generally accepted system on how this is done in current practice. FM professionals and software providers may use the information in this paper to establish baseline sets of data to include in BIM during the design phase of projects. This paper provides insight and data as to the current practice of asset management by facility managers. Understanding the actual needs of the FM industry will assist in future research to implement BIM for FM.

Keywords: Building Assets; Building Information Model (BIM); Facility Management; COBie; Asset Attributes; BIM for FM

Introduction

The use of Building Information Modelling (BIM) has become more prevalent in the design and construction phases in the life of a building. BIM is defined as the "digital representation of physical and functional characteristics of a facility" and may also refer to "a shared knowledge resource for information about a facility" (National Institute of Building Sciences, 2017). BIM provides the architects, engineers, contractors, and owners (AECO) with valuable data to ensure that their project progresses smoothly but are seldom used after construction. BIM has a reported 71% adoption rate in the architecture, engineering, construction (AEC) industry as of 2012 (McGraw-Hill Construction, 2012). Conversely, that same report shows that building owners use BIM at a rate of less than 25% for most facility management (FM) and operation and maintenance (O&M) activities. However, the design and construction of a building are relatively short-term processes in relation to the building's overall lifespan. The recent U.S. Census Bureau reports that the average length of time for construction of all project types is 7.6 months (U.S. Census Bureau, 2016), while the median age of buildings is 32 years (U.S. Energy Information Administration, 2016). The creation of a BIM solely for construction does not fully utilize its potential as an ongoing source of information for the FM personnel in charge of operating, maintaining, and sustaining a building.

Facility managers currently use Computer-Aided Facility Management (CAFM) systems and Computerized Maintenance Management Systems (CMMS) to address the needs of the built environment. The CAFM systems "typically provide and maintain information on floor plans, property descriptions, space utilization, energy consumption, equipment locations, and other critical infrastructure data that pertains to the sector it is serving" (Watson & Watson, 2016). As Roper and Payant (The Facility Management Handbook, 2014) note, an Integrated Workplace Management System (IWMS), also known as a CAFM, may include real estate and lease management, space management, budget and other financial concerns, and many other aspects of a company's portfolio of assets and processes. The CMMS, as the name suggests, is geared more towards the maintenance of a facility. A CMMS "assists the facilities maintenance manager with work reception, planning, control, performance, evaluation, and reporting" (Sapp, 2016). If a BIM were populated with data that could be extracted by an FM software system, then the facility manager, whether as an owner, operator or occupier, could benefit from the use of BIM as a tool for the ongoing operations and management of the building. However, as Reddy (BIM for building owner and developers, 2012) stated, the focus of standardization for

BIM has been on the model, not the information contained in the model. A system for the information transfer, the Construction Operations Building information exchange (COBie) was created to provide a process to transfer non-geometric building data from machine to machine (East, Nisbet, & Liebich, 2012). However, even with COBie, there is a lack of a set standardized information that could be used by the AEC and FM industries to assist in the preparation of a BIM for FM. The purpose of this paper is to discover the current methods that facility managers use to manage and track assets and to identify a set of attributes for a BIM that can improve the efficiency of the current FM practice.

Literature

The process of facility handover from contractors to owners has been a challenge especially for owners to retrieve essential building information for effective O&M. During the traditional process of handover, not only an information bottleneck occurs but also the process is often involved with time consuming and error prone 'hard-data entry.' The overarching goal of creating a BIM for FM is to make the process of data management and the O&M of the facility more efficient. However, owners have been struggled defining 'essential' building information for effective O&M and the 'value' of information, thus tend to collect all information possible for the just-in-case need (Mayo & Issa, 2015). Even when owners have BIM requirements, their requirements and specifications have a great variability in terms of the level of detail (Cavka, Staub-French, & Poirier, 2017; Korpela, Miettinen, Salmikivi, & Ihalainen, 2015). Moreover, existing BIM policies, standards, guidelines, and protocols around the globe are inconsistent and do not encourage owners to transit towrads BIM-enabled project delivery and FM (Cavka et al., 2017).

Becerik-Gerber, Jazizadeh, Li, and Calis (2011) used a survey of facility managers to compile the potential application areas for a BIM-FM model. The survey respondents were both BIM users and non-BIM users, across organizations involved in the architecture and FM professions. The leading application for both groups is "locating building components." This result illustrates the most basic need for a facility manager – finding the equipment in a building. The location information on the equipment is necessary for simple preventive maintenance, or for emergency situations where quick access is paramount. Owners also indicated strong needs for building information regarding 1) security and emergency planning related facility and occupant protection products and 2) HVAC-specific products and equipment (Mayo & Issa, 2015). Keady (2013) states that "the goal for any premiere facility management team should be to have a component-level equipment inventory for all disciplines."

Having a BIM-FM model that includes the correct location of equipment would seem to be an easy task, especially in a new construction project where these items are included in schedules and specifications. For a project that is a stand-alone facility, the creation of the inventory list may be a simple procedure that is based solely on the equipment in that building without consideration to global identifiers. For a large enterprise that includes a building as part of a campus or portfolio, however, systematic asset tracking tools are required to record and keep track of the building components.

The most efficient way to create an inventory is to use a standard system of identification for equipment components. Reddy (2012) states that "historically industries that develop high levels of standardization typically benefit more than those developing their own unique standards." For the construction industry, the most applicable standard for asset tracking is OmniClass™. Keady (2013) concludes that "OmniClass™ is an object-oriented, open, and commonly used standard that is used by multiple industries, especially the construction industry, and therefore it is the ideal standard for use by facility management for equipment inventories." In construction documents, the specifications often use MasterFormat® to classify work results for the different systems of a building. This standard is also used for cost estimating purposes and can be helpful in classifying building systems. However, it is not object-oriented and is not an open standard, so it should not be used for equipment identification. The other common standard in construction is UNIFORMAT II, a systems-based identification system that sometimes uses the function as an identifier instead of type. This system is not recommended because it is not an open standard and may require the addition of self-generated information (Keady, 2013). When using OmniClass™, Table 21 is the 'Elements' table and Table 23 is the 'Products' table. An Element "fulfils a characteristic predominate function, either by itself or in combination with other elements" (OmniClass Development Committee, 2015). The OmniClass™ system is also the preferred system for BIM as recommended by the National Institute of Building Sciences (NIBS). Aligning the equipment inventory with the OmniClass™ system will facilitate the transfer of information from the BIM-FM model to CMMS.

The Construction Operations Building information exchange (COBie) was designed for machine-to-machine transfer of data. When a BIM is created, the COBie standard creates the spaces in a building and may assign areas as rooms or zones. This allows the placement of equipment in those areas and creates a file that transfers the space and equipment data from the BIM to a CMMS. The COBie standard is flexible as to the list of attributes for each equipment item. However, this is also a barrier for effective implementation since there is neither a set list of attributes nor a consistent list of attributes that covers all equipment types. Correctly identifying rooms and zones for the BIM for FM model is essential for proper placement of equipment.

Methods

FM:Systems, a software company that specializes in facility management applications, sponsored a BIM-FM Consortium with the intent of shaping guidelines for the use of BIM throughout the life cycle of a building. The Consortium included AECO professionals, FM: Systems software users, research partners from the Georgia Institute of Technology and members of the FM:Systems management team. The professional participants were required to have experience with using BIM in facility management settings (Schley, 2015). The Consortium met via conference call for semi-regular monthly meetings over one year, with one face-to-face meeting. The data for this paper is a result of the survey that was created through the Consortium. In developing the survey, the Consortium focused on questions that would establish a baseline of information that could be analyzed for current trends in the FM industry. There are 15 questions in the survey that ask a range of questions from current FM practices to opinions on BIM for FM. The goal of the survey was to answer the following questions:

- Who and what sector of the FM profession is currently tracking assets?
- What are the current practices for asset management?
- What is the strategy for tracking assets and attributes?
- What is the basic information should be included in a BIM-FM?

As host of the Consortium, FM: Systems facilitated the online survey via Survey Monkey. The survey opened on August 24, 2015 and closed on September 28, 2015. The target audience for the survey included members of APPA: Leadership in Educational Facilities (APPA), Campus FM Technology Association (CFTA), International Facility Management Association (IFMA), and Health Care Institute (HCI). The survey had 116 total responses, 7 surveys were deemed incomplete, giving an actual total of 109 responses.

Results

The first three questions in the survey established the demographic of the respondents with respect to their job function, industry sector and a number of buildings within their scope of responsibility. The job function results are shown in Table 1, where facilities directors/managers and FM related computer systems administrators accounted for roughly 40% of the respondents. The job descriptions were pre-populated for the survey. The 'other' category for job function description included an option to specify job title, and the answers were wide ranging within the FM field. GIS Manager, Space Planner, and Architect were among the self-reported titles.

The question for industry sector had two clear leaders – Education and Healthcare with 31.2% and 23.9%, respectively. The next two largest response groups were Government at 8.3% and Finance and Financial Services with 5.5%. The complete list of industry sectors is given in Table 2, again, the list of choices was pre-populated for the survey. In the 'other' category, two respondents listed Professional Services, and one each listed Law Firm, Facility Management, and Medical Centre (a combination of Healthcare, Research, and Higher Education).

TABLE 1.—Job Function

Job Function Description	Count	Percent
Facilities Director (or Facilities Manager)	27	24.8%
IWMS/CMMS/CAFM Systems Administrator	18	16.5%
Facilities Asset Manager	9	8.3%
Facilities Planner	7	6.4%
Facilities Administrator	5	4.6%
Facilities Engineer or Technician	5	4.6%
Chief Executive	3	2.8%
Real Estate Director or Manager	3	2.8%
Facilities Operations Manager.	3	2.8%
Maintenance Manager	2	1.8%
Other	27	24.8%

In most cases, the respondents surveyed monitor many buildings, with 50.9% in charge of fifty or more buildings, while 23.1% have a range of eleven to fifty buildings. Only two respondents monitor a single building. The correlation of industry sector and number of buildings yielded a significant result ($N = 106$, $DF = 60$; Likelihood Ratio Chi-Square $= 99.336$, $p = 0.0011$; Pearson Chi-Square $= 117.355$, $p < .0001$), however the results are suspect given the average count of less than five for most cells. In the largest industry sector, Education, no respondent chose less than 11 buildings, with the majority (85.29%, 29 of 34) choosing 50 or more buildings. While Healthcare, the second largest group, had results spread across all five choices. The complete list of buildings per industry sector is given in Table 3, with the industry sectors still ranked by response group. Note that one respondent (from Construction, Machinery, and Homes) skipped this question.

Table 4 illustrates the use of published industry standards or internally developed guidelines for managing how the respondents describe and track building assets. The results of this correlation are statistically significant ($N = 106$, $DF = 8$; Likelihood Ratio Chi-Square $= 26.049$, $p = 0.0010$; Pearson Chi-Square $= 22.739$, $p = 0.0037$) and show a preference of internally developed guidelines over published industry standards or no standards. Of the 34 Education industry respondents, 6 used no standards, while 14 each used an internally developed guidelines or industry standards. In Healthcare, only 1 did not use a standard or guideline, while 21 of 25 used internally developed guidelines, leaving 3 to use industry standards. For the Government sector, 6 used internal guidelines, and the remaining 3 used industry standards.

Additionally, respondents were asked to list the current standards in use, and fifteen of the twenty-two complied. Identified standards included RS Means, the Postsecondary Education Facilities Inventory and Classification Manual (FICM), Construction Specifications Institute (CSI) UniFormat, CSI OmniClass, and COBie. Two respondents

TABLE 2.—Industry Sector

Industry Sector	Count	Percentage
Education	34	31.8%
Healthcare & Pharmaceuticals	26	24.3%
Government	9	8.4%
Finance & Financial Services	6	5.6%
Insurance	4	3.7%
Manufacturing	4	3.7%
Construction, Machinery, and Homes	3	2.8%
Real Estate	3	2.8%
Telecommunications, Technology, Internet & Electronics	3	2.8%
Airlines & Aerospace (including Defense)	2	1.9%
Business Support & Logistics	2	1.9%
Nonprofit	2	1.9%
Utilities, Energy & Extraction	2	1.9%
Entertainment & Leisure	1	0.9%
Food & Beverage	1	0.9%
Other	5	4.7%

indicated that COBie is their standard, and two others indicated that they are moving to COBie. Four respondents indicated an internal guideline in combination with an industry standard.

To determine the operation and management of buildings, the respondents were asked to identify the occupancy trait and FM staffing style. The occupancy traits of the respondents include owner/occupier and lessee. This resulted in three traits – only own the buildings, only lease the buildings, and the combination of own and lease. The FM staffing style included four choices – staff who manage facility operations, outsourcing of facility operations, staff who manage facility maintenance, and outsourcing of facility maintenance. Table 5 shows that the greater number of respondents both own and lease properties. Accordingly, 73.4% of the respondents have staff who manage facility operations, 78.9% have staff who manage facility maintenance and repair, and 33.9% have staff that do both with no outsourcing. Only 24.8% of the building owners outsource facility operations, with 36.7% outsourcing

TABLE 3.—Number of Buildings by Industry Sector

Industry Sector	1	2-5	6-10	11-50	50+	Total
Education	-	-	-	5	29	34
Healthcare & Pharmaceuticals	1	6	3	11	5	26
Government	-	1	-	1	7	9
Finance & Financial Services	-	-	1	1	4	6
Insurance	-	1	1	1	1	4
Manufacturing	-	-	3	-	1	4
Construction, Machinery, and Homes	-	1	-	1	-	2
Real Estate	-	1	-	-	2	3
Telecommunications and Technology	-	-	-	2	1	3
Airlines & Aerospace (including Defense)	-	-	1	-	1	2
Business Support & Logistics	-	-	2	-	-	2
Nonprofit	-	2	-	-	-	2
Utilities, Energy & Extraction	-	-	-	1	1	2
Entertainment & Leisure	-	-	-	1	-	1
Food & Beverage	-	-	1	-	-	1
Other	1	1	-	1	2	5

TABLE 4.—Number of Buildings and Use of Industry Standards and Internal Guidelines

No. Buildings	Percentage	Internal Guidelines	None	Industry Standards
1	1.9	0	1	1
2-5	12.3	12	0	1
6-10	12.3	8	5	0
11-50	21.7	15	5	3
50+	51.9	34	4	17
Total	100	69	15	22

maintenance and repair. None of the respondents outsource maintenance and operations exclusively, while 18.3% use all four options for maintenance and operations.

A contingency analysis of the occupancy trait versus the operations and maintenance data shows a significant relationship ($N = 89$, $DF = 16$; Likelihood Ratio Chi-Square $= 42.454$, $p = 0.0003$; Pearson Chi-Square $= 59.205$, $p < .0001$) between organizations that own buildings and the methods of facility operations and management. For occupants that only own buildings, 20.22% have staff that exclusively perform operations and management with no outsourcing, while those that own and lease have a similar rate at 21.35%. However, occupants that only lease have zero staff dedicated to operations and management. The own and lease group reported a 19.10% rate of using a mixture of in-house staff and outsourcing for all operations and maintenance, while those that only owned and only leased were at 2.25% and 1.12%, respectively. Similarly, 11.24% of occupants that both own and lease use the combination of staff operations, staff maintenance, and outsourcing maintenance.

Understanding the current processes of facility management is an important step in identifying the minimum information needed for BIM. Asset tracking may involve several data points and provide a wide range of data categories. The surveyed respondents identified which attribute of an asset that they track, or plan to track. Fourteen attributes were listed to choose from, with an option to select multiple attributes (Table 6). The top five attributes by total count were chosen by 64.7% of the respondents: asset type, asset ID, model number, serial number, and manufacturer. Additionally, 14.7% chose all 14 attributes, while the average number of attributes selected was 8.29.

Correlating the list of attributes with the number of buildings managed did not produce statistically significant relationships. A contingency analysis of the list of attributes and the use of industry standards or internal guidelines revealed three statistically significant relationships. The first relationship tied the use of an internal guideline to the asset

TABLE 5.—Occupancy Trait

Occupancy Trait	Count	Percentage
Own	39	35.8%
Lease	7	6.4%
Own and Lease	53	48.6%
No Response	10	9.2%

TABLE 6.—Attributes Currently Tracked

Attribute	Count	Percentage
Asset Type	87	85.3%
Unique Asset ID	85	83.3%
Model Number	85	83.3%
Serial Number	84	82.4%
Manufacturer	82	80.4%
Installation Date	69	67.6%
Date Placed in Service	56	54.9%
Warranty Start Date	56	54.9%
Purchase Cost	49	48.0%
Warranty in Days	44	43.1%
Life Expectancy	44	43.1%
Nameplate Data	38	37.3%
Replacement Parts	35	34.3%
Installed By	32	31.4%

type attribute (($N = 100$, $DF = 2$; Likelihood Ratio Chi-Square = 10.365, $p = 0.0056$; Pearson Chi-Square = 13.283, $p = 0.0013$). This relationship indicated that 59% of respondents using an internal guideline also tracked the asset type. The second relationship showed that warranty in days is less likely (44%) to be used when an internal guideline is used (($N = 100$, $DF = 2$; Likelihood Ratio Chi-Square = 12.267, $p = 0.0022$; Pearson Chi-Square = 12.064, $p = 0.0024$). And finally, nameplate data is also less likely (48%) to be used when an internal guideline is used (($N = 100$, $DF = 2$; Likelihood Ratio Chi-Square = 17.347, $p = 0.0002$; Pearson Chi-Square = 17.597, $p = 0.0002$).

Another question regarding current tracking procedures addressed the location of the assets. The levels of location listed site, building, floor, suite or zones, room or space, grid system (geo-referencing), and other as choices. The majority (65.4%) of the respondents chose 'room or space' as the location level. 'Building' followed with 14.0% of the responses, 'floor' and 'other' each received 5.6%, 'Site' was chosen by 3.7%, and 'suite or zones' and 'grid system' each received 2.8%. Comparing the number of buildings managed with the tracking level did not show a statistically significant result.

The granularity, or level of detail, currently used to track most of facility assets was questioned with respect to unique identification (ID), compliance data, performance data, and use of a digital repository for more in-depth data. Over 95% of those surveyed indicated that assets are tracked by using a unique ID. The choices for collecting performance data and compliance data did not indicate any specific quantity or reference for the data. However, the choice that includes maintaining digital data specifically mentions a digital repository of specification data normally found on printed drawings and submittals. Two of the respondents that chose 'other' indicated that they did a combination of the choices, while two indicated that they are just beginning to develop an asset database. A contingency analysis of the granularity level compared with the occupancy trait did not return a statistical significance. Likewise, the contingency analysis of the type of FM, staff or outsource, did not reveal a correlation.

TABLE 7.—Level of Detail for Tracking Assets

Description	Count	Percentage
Track assets with unique ID and collect performance data	33	30.8
Track assets with unique ID	26	24.3
Track assets with unique ID and collect compliance data	17	15.9
Track assets with unique ID and maintain digital data	16	15.0
We do not track our assets	10	9.3
Other	5	4.7

A contingency table that compares the tracking level location and information in Table 7 does show a statically significant relationship between the tracking level and the level of detail ($N = 107$, $DF = 30$; Likelihood Ratio Chi-Square = 45.308, $p = 0.0361$; Pearson Chi-Square = 48.256, $p = 0.0187$). In this correlation, most respondents (70) track assets according to 'room or space' and collect data on the assets. However, 20% of the cells in the comparison have a count less than 5, making the results suspect.

When ranking the importance of the tracking information for facility assets, 'preventive maintenance' returned the best overall mean score of 3.38 on a scale of 1 to 9, with 1 being the most important. However, the most common choice for 'most important' was inventory. The complete results and list if given choices are shown in Table 8.

In a similar question, respondents were asked to choose the reasons for tracking information related to facility assets (Table 9). Preventive maintenance was the most common choice on this list, followed by inventory, mirroring the results in the ranking question (Table 8). Respondents were asked to choose all that applied, and the average number of choices selected was 4.39.

A contingency analysis of the tracking information choices showed a statistically significant relationship between occupancy trait (own, lease, or own & lease) and inventory ($N = 94$, $DF = 2$; Likelihood Ratio Chi-Square = 9.466, $p = 0.0088$; Pearson Chi-Square = 7.910, $p = 0.0192$). In this analysis, a majority of all three occupancy types listed 'manage inventory' as a reason for tracking information. The same test did not show a significant relationship between occupancy trait and any other reason for tracking information. This supports the result of inventory as the most chosen option in the ranking question.

The survey included two questions regarding formalized data maintenance plans (Table 10). The first of the two asked if the respondents have a plan for maintaining facility asset information during design and construction (DC), and the second asked if there is a plan for maintaining asset information during facility management (FM). Both questions are yes/no and included an option for 'other' with a comment box. For the DC question, out of 99, 45 answered 'yes' to the data plan, 44 answered 'no' and 10 answered 'other'. The FM question totals are 69 for 'yes', 23 for 'no', and 7 for 'other' out of 99. Of the 10 that answered 'other' for the DC question, 7 indicated that a plan is in

TABLE 8.—Ranked Reason for Tacking Asset Information

Reason for Tracking Information	Mean Score	Count Most Important	Count Least Important
Preventive Maintenance	3.38	22	1
Inventory	4.23	29	11
Corrective Maintenance	4.51	7	2
Easily Locate	4.73	6	8
Planned Maintenance	4.84	7	6
Compliance	5.35	13	20
Predictive Maintenance	5.48	4	8
Emergency Shut-off	5.76	6	11
Assignment (Individual, Dept.)	5.89	6	23

development. Likewise, 5 of the 7 that answered 'other' for the FM question indicated that a plan is in development.

The contingency analysis of the two questions show a significant relationship ($N = 99$, $DF = 4$; Likelihood Ratio Chi-Square $= 41.552$, $p < 0.0001$; Pearson Chi-Square $= 45.817$, $p < 0.0001$), with almost half the respondents using data maintenance plans in both DC and FM. There was no statistical relationship between the data maintenance plans and number of buildings managed. The data maintenance plans are not tied to the use of industry standards or internal guidelines either.

Three questions in the survey asked the opinions of the respondents with regards to the use a BIM for FM model. The first question addressed the level of detail (LOD) for asset representation in the model. The respondents selected one of five choices – symbols, simple geometric shapes, geometric shapes to scale, generic BIM objects, and manufacturers BIM objects – that represented increasing LOD for the asset representation. Each object would have an associated ID tag. The 'symbols' choice would require no effort beyond the standard alpha-numeric tags present in the asset schedules and would give general location information. Likewise, 'simple geometric shapes' would represent the estimated space and location of the asset. 'Geometric shapes to scale' would require the specific dimensions of the asset, this information may not be available during the design phases of a project. 'Generic BIM objects' would provide greater detail but may differ from the actual 'manufacturer's BIM object'. However, the generic object may be the highest LOD if the manufacturer does not provide a BIM object. As Table 11 shows, there is no clear preference to the LOD question.

TABLE 9.—Reasons for Tracking Asset Information

Reasons for Tracking Information	Count	Percentage
Preventive Maintenance	78	75.0
Manage Inventory	72	69.2
Corrective Maintenance	60	57.7
Easily Locate	58	55.8
Compliance	55	52.9
Assignment	53	51.0
Predictive Maintenance	41	39.4
Emergency Shut-off	40	38.5

TABLE 10.—Data Maintenance Plan Strategies

Description	Count	Percentage
Data maintenance plan for DC & FM	43	43.4%
Data maintenance plan for FM only	21	21.2%
No data maintenance plan for DC nor FM	21	21.2%
FM data maintenance plan, 'other' DC plan	5	5.05%
'Other' data maintenance plan for FM and DC	4	4.04%
No data maintenance plan for DC, 'other' for FM	2	2.02%
Data maintenance plan for DC only	1	1.01%
Data maintenance plan for FM, other for DC	1	1.01%
Data maintenance plan for DC,	1	1.01%

The second opinion question addressed three aspects of using a BIM for FM model with regards to data content and importance of locating equipment. For data content, the question addressed both the inclusion of spare or replacement part information for equipment and the inclusion of warranty data in the model. All three aspects were measured using the same Likert scale choices as seen in Table 12.

There is no statistical significance to the answers in Table 9 since including the 'depends on equipment choice' created a lack of an indexed scale to analyse the question. However, it is evident from the responses that inclusion of spare parts data is driven more by equipment type than by the opinion of importance. Conversely, warranty data information is deemed very important by most (41%) respondents. There is no majority opinion on using a BIM for FM model for locating equipment.

The final opinion question addressed the inclusion of equipment attributes in a BIM for FM model. The respondents were asked to choose 5 attributes that, at a minimum, should be included in a BIM for FM model. The results for this question are shown in Table 13. 64% of the respondents limited their choice to just 5 attributes as directed, with others choosing anywhere from 1, to all 14, of the attributes. The median number of attributes chosen was 6.2, with 36% of all respondents choosing the top 5 in the list. However, only 16% chose just the top 5 attributes.

Analysis of this question did not yield statistically significant results when compared with the other opinion questions. Likewise, no relationships were found when comparing this data to the number of buildings managed or the current use of building standards. Comparing this data to Table 6, Current Asset Tracking, reveals the same top five choices but in a different order (Table 14).

TABLE 11.—Proposed Level of Detail for Asset Representation in BIM for FM

Object LOD	Count	Percentage
Symbols with ID Tag	25	27.2
Generic BIM Object with ID Tag	21	22.8
Manufacturer's BIM Object with ID Tag	16	17.4
Simple Geometric Shape with ID Tag	15	16.3
Geometric Shape to Scale with ID Tag	15	16.3

TABLE 12.—Proposed Importance of Asset Aspects

Description	Not Important	Somewhat Important	Very Important	Depends on Equipment Type
Inclusion of Spare Parts	16	21	17	42
Inclusion of Warranty Data	13	20	40	24
BIM for Locating Equipment	13	23	29	32

Discussion

This survey cast a wide net and gathered a broad spectrum of information. Even with a focus on specific industries, the answers were far-ranging across many of the subjects. Beginning with a question as seemingly simple as 'job function', this survey revealed that there was no clear definition of the facility manger job. The role of a facility manager may be a management or executive position, a planner or an engineer, or a designer or analyst. As for industry, this survey targeted the Education and Healthcare sectors since both had professional originations (APPA, CFTA, HCI) that were specific to FM. The percentages of industry response were congruent with the target audience; Education accounted for 31.8% and Healthcare 24.3% (Table 2). Since these industries also are inclined to have a campus in lieu of a single building (Table 3), the management of assets would require more organizational efforts. Similarly, the use of industry standards or internally developed guidelines to track assets would most likely be in use by these organizations. The survey showed that only 15 respondents out of 106 used neither industry standards nor internal guidelines, 6 of those in Education, 1 in Healthcare.

As expected, the survey showed that the majority (86%) of facility managers were tracking assets in their buildings. However, there was no clear consensus as to how assets were tracked (Table 7) with respect to the level of information collected or the use of the information. Since there are many different job functions in the industry, it is understandable that different FM functions would require different types of data. For instance, a facilities/space planner would most likely require less operational data than a maintenance manager. There was no significant association between job function and the level of data collection. Nor did the survey include a list of assets regarding type; e.g. mechanical equipment or furniture. The type of assets tracked were deemed important when choosing aspects of information to include in a BIM for FM model (Table 12). A complex machine, such as a mechanical chiller, would require spare parts and warranty data, while a simple office desk would not. Correlating the asset tracking to specific items could have provided a better idea of the current trends. Notably, facility managers who used internally developed guidelines were less likely to track warranty in days than those who used industry standards. A contractor's warranty for materials and workmanship is generally up to three years and shorter than other warranties (Scott, Ferragut, Syrnick, & Anderson, 2011). A manufacturer's warranty for building equipment and products, however, is usually longer than a contractor's warranty. Manufacturers' warranties for HVAC units and roofing material, for example, usually range from 5 to 15 years and 10 to 30 years, respectively. Considering different length of warranty periods and relatively long periods for certain equipment and products, the respondents' perceived importance of having warranty data was high. However, the current warranty tracking practice reported in this study did not fully reflect the respondents' perceived importance of having warranty data (Table 12).

TABLE 13.—Recommended Equipment Attributes for BIM for FM

Description	Count	Percentage
Asset ID	80	81.6
Model Number	79	80.6
Manufacturer	77	78.6
Serial Number	70	71.4
Asset Type	68	69.4
Installation Date	44	44.9
Warranty Start Date	35	35.7
Life Expectancy	31	31.6
Nameplate Data	29	29.6
Date in Service	27	27.6
Warranty Days	20	20.4
Replacement Parts	18	18.4
Purchase Cost	16	16.3
Installed By	14	14.3

TABLE 14.—Comparison of Tracked Attributes to Recommended

Description	Currently Tracking	Recommend Tracking
Asset Type	87	68
Unique Asset ID	85	80
Model Number	85	79
Serial Number	84	70
Manufacturer	82	77

Additionally, the survey illustrated that there was no common practice used for collection of data. The majority response to the use of standards indicated that internally developed guidelines were used to describe and categorize assets. The use of published industry standards such as OmniClass™ and COBie was limited, with less than 10% of those surveyed specifically listing a standard. Since BIM for FM is not widely used, these results are not surprising, especially when COBie is specifically intended for BIM. The full adoption of COBie may be difficult for large organizations that have a fully developed internal guideline in use. The cost to change the identification of assets from one method to another may be a barrier. Likewise, existing software used for maintenance or asset management may require reprogramming. Need may be an additional barrier to adoption since organizations that have internally developed guidelines may not see a reason to change.

The strategy for tracking assets begins with the collection of the identification data for assets, with most respondents categorizing and assigning a unique asset ID to the asset.

The location of the asset is most commonly tracked to the specific room or space in the building. And while inventory ranked high in the reason for tracking assets and was chosen second as a reason for tracking assets, the main reason for tracking assets is preventive maintenance. The study by Becerik-Gerber et al. (2011) indicated that location of assets would be a primary use for BIM for FM, but the results of this survey suggested that maintenance had a higher priority. Preventive maintenance scores the highest in both ranking and reason for tracking assets, and corrective maintenance is third in the reason for tracking assets. This survey did not ask questions that addressed the type of data used for maintenance, it only addressed the general information that could be used to identify assets. Like the issue of warranty data and spare parts, locating equipment had no clear majority as to the importance of using BIM for that purpose. But it was deemed not important by only 13 of 97 respondents.

The questions addressing the basic information needed for a BIM for FM did not yield clear results in the LOD category or the equipment location aspect. The current practice for identifying and locating equipment on blueprints is an alpha-numeric symbol tag that relates to a given schedule. That option had that the highest count, followed by the generic BIM object (Table 11). These results would indicate that FMs are not as concerned with an actual depiction of the asset but would prefer a BIM object over a geometric shape. Using a manufacturer's BIM object may only be necessary in dedicated equipment rooms, where dimensions are important for space utilization. If the BIM for FM is used by space planners, the manufacturer objects would be helpful too.

There is a clear delineation shown in Table 13 as to the recommended equipment attributes for BIM for FM. The top five choices scored over 69% in response count, while the highest of the rest was 44.9%. Unfortunately, this question did not limit the number of selections to five, and there were many respondents that chose more than the requested number. It is probable that limiting the answers to only five responses would have given a different result.

It is interesting that the top five attributes chosen are all forms of identification, and no operational information made that cut. Of the five, only serial number requires the actual piece of equipment. The other four – asset ID, model number, manufacturer, and asset type – may be identified in the preconstruction phase of a project. For new projects, the inclusion of manufacturer and model number information in the design of BIM would be possible once product submittals have been approved by the design team. For asset ID and type, the data would depend on internally developed guidelines or published industry standards that are identified in the planning stages. Additionally, since the majority (65.4%) of FMs track assets to the room or space LOD, the identification and proper labelling of those areas will be important during the design phase. Although 86% of respondents tracked the assets only 43.4% had data maintenance plan strategies during the design, construction, and facility management phases. Considering that four out of top five forms of asset identification are specifiable during the planning and design phase, effective data maintenance plan strategies should be placed in the early stage of a building's lifecycle. For future study, organizations' specific strategies of data maintenance plans can be investigated to advance industry practices and develop standardization.

The remaining attributes on the list, except for nameplate data, provide operational information. In general, this information is necessary for specific purposes such as maintenance, and not necessary for all types of equipment. Narrowing the scope of asset types, or pairing asset categories with attribute groups may provide a better idea of the basic BIM for FM requirements. Furthermore, understanding the use of CAFM or CMMS by the FMs with respect to the attributes may provide deeper insight in this topic.

In general, the strength of this study is the participation of over one hundred respondents in the FM field. Targeting the Education and Healthcare industries ensured input from FMs that manage more than one building, and probably more than one type of building. The breadth of the survey provides an overview as to current FM practices in industry. However, more specific data, or better question construction to extract the data, would be beneficial for future studies. Conversely, by targeting a group of FMs in industries that have long asset histories, such as academic campuses, the data may not represent the adoption of the latest technologies and tools. There may be a tendency of these groups to maintain a status quo of asset tracking that is not, or may never, use published industry standards, COBie, BIM or FM software systems.

Conclusion

This paper sought to discover the current methods that facility managers use to manage and track assets and identify a set of attributes for a BIM for FM that can improve the efficiency of the current FM practice. The findings of the survey show that FMs are tracking assets with a variety of means and methods. The job description, occupancy trait and O&M methods data revealed a broad grouping of strategies for FM. And while there is no evident universal best practice, the majority of FMs agree on the basic information needed for a BIM for FM. In general, the identification of assets was deemed most important. However, the prevalence of maintenance information as a reason for tracking assets by the FMs demonstrates that there is a desire to have a data set that may assist in planning maintenance activities.

Having the FMs invloved in the design process may help with the efficiency of data selection, since the survey reveals that equipment type is an indicator of the necessary information for a BIM. The FM may have a specific performance data requirement for certain types of assets. Likewise, having correct room or space identification strategies during the design phase of new projects will help

to populate data information transfers schemes such as COBie.

This study did not address specific asset types or equipment maintenance needs. Future studies would benefit this topic by including information on data necessary for categories of assets. The cost of adding data to the design of BIM and the identification of responsible parties for asset ID strategies is also not included in this study. It is plausible that BIM data requirements could be standardized in project specifications to ensure that data is available for BIM for FM. Having the basic data set available in the design of BIM could enable FMs and software manufacturers to easily extract useful information for the BIM for FM.

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