Introduction

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MANAGEMENT SUMMARY

Figure 1.1 summarizes the main benefits that an owner can expect from integrating building information modeling (BIM) and facility management (FM). These are explored in further detail later in this chapter, and the rest of the book explains the technology and processes that can be used to achieve this goal. The primary goal of this book is to help owners and practitioners understand how to successfully implement BIM FM integration to achieve the benefits shown in this diagram.

This chapter begins with a description of current FM practice and the inefficiencies caused by poor data storage and lack of interoperability among the information systems that are used for design, construction, and facility management. These were documented in a December 2004 National Institute of Standards & Technology (NIST) study titled *Cost Analysis of Inadequate Interoperability in the U.S. Capital Facilities Industry* (NIST GCR 04-867). The additional cost of interoperability represents about 12.4 percent of total annual cost, which is significant as this occurs over the operational life of the building.

The second section of this chapter then identifies how BIM FM integration can address these problems and calculates the return on investment (ROI) that can be achieved by an investment in this technology and its associated processes. The results are rather startling: ROI is about 64 percent, with a payback period of 1.56 years. While the assumptions made in this analysis are tentative,

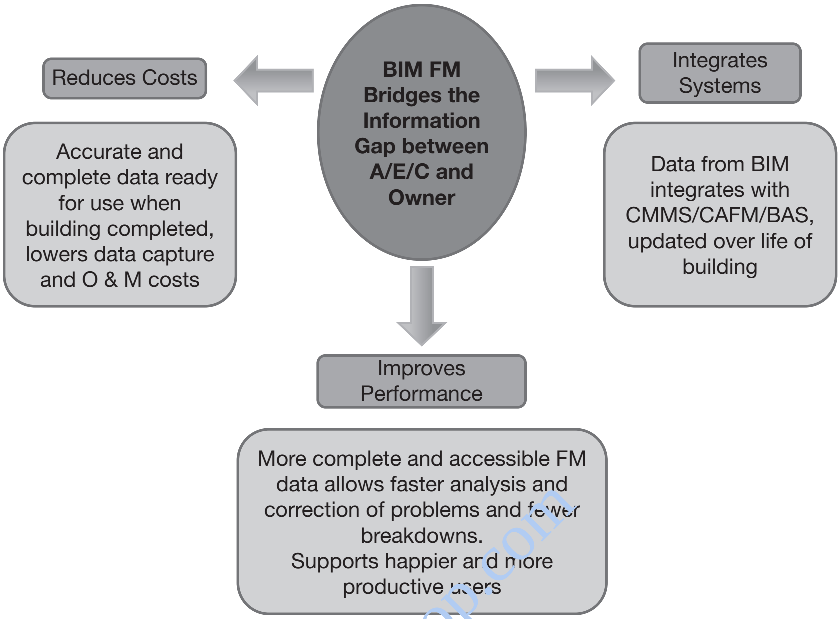

FIGURE 1.1 Summary of the main benefits that can be achieved by BIM FM integration.

they are quite conservative, and the results indicate that BIM FM integration, when done correctly, can provide very significant owner benefits. These benefits come from savings in the collection of data over the design and construction process rather than waiting until the completion of the building, and the intelligent use of a digital database of building information that allows FM managers and staff to make better and faster maintenance decisions and provide higher-quality building performance. The same database can also support more informed use of the building and its modifications over its life. These are very significant issues for all owners and operators of buildings.

The remainder of the chapter describes what can be found in the remaining five chapters of the book so that the reader can determine the best approach to reading this book based on their interests and background.

PROBLEMS WITH CURRENT FM PRACTICE

When one considers the extensive documentation of information needed for effective maintenance and operation of most facilities, it is clear that finding efficient ways to collect, access and update this information is very important. Most existing buildings have this information stored in paper documents (rolls of drawings from the architect and engineers, folders of equipment information for each type of equipment, file folders of maintenance records, etc.). This documentation is normally contractually requested by the owner and handed over after the building is already in use, often months later, and stored in some basement office where it is difficult to access. This is illustrated in Figure 1.2a and 1.2b showing actual storage of FM documents.

FIGURE 1.2a Picture of document storage for FM information after turnover by the contractor.
Courtesy EcoDomus, Inc.

FIGURE 1.2b Picture of document storage for FM information after turnover by the contractor.
Courtesy EcoDomus, Inc.

In December 2004 NIST published a study titled *Cost Analysis of Inadequate Interoperability in the U.S. Capital Facilities Industry* (NIST GCR 04-867).[1] This often-cited analysis of the cost impacts of the lack of data interoperability on architects, engineers, contractors, and owners was the first serious effort to quantify these impacts on all stakeholders and over the building life cycle. A quote from this report summarizes the impacts on owner/operators of problems described earlier:

> An inordinate amount of time is spent locating and verifying specific facility and project information from previous activities. For example, as-built drawings (from both construction and maintenance operations) are not routinely provided and the corresponding record drawings are not updated. Similarly, information on facility condition, repair parts status, or a project's contract or financial situation is difficult to locate and maintain.

For the owner who has decided to use a computerized maintenance management system (CMMS), it is necessary to transfer this equipment and other building information into digital files. Normally, this is done manually by the FM personnel as time permits. Thus, effective use of the system is delayed until it contains the necessary data and these data have been checked for accuracy and completeness. A similar comment applies to the use of computer-aided facility management (CAFM) systems. The cost and time associated with entering, verifying, and updating the information in these systems contributes to the costs identified in this report.

Section 6.5 (pp. 6-16, 17) of this report discusses the additional costs that impact owner/operators. While this is too detailed to reproduce here, the data are summarized in Tables 1.1 and 1.2 and illustrated in Figure 1.3.

We see that owners and operators represent about two-thirds of all these costs, and that they occur over all phases of the life cycle, with most of this cost in the operations and maintenance phase (57.5 percent).[2] The added cost for operations and maintenance (O&M) is $0.24 per SF or, based on the 2009 International Facility Management Association (IFMA) Maintenance Survey,[3] or 12.4 percent of total annual mean O&M costs,[4] which is significant as this occurs over the operational life of the building.

Table 1.2 shows that avoidance and mitigation form the bulk of the costs incurred by owner/operators.

[1] Available at www.nist.gov/manuscript-publication-search.cfm?pub_id=101287.

[2] The unit costs for the design and construction phases are based on 1,137 million SF of new construction in 2002. The unit costs for O&M are based on 38,600 million SF of new and existing buildings.

[3] Available at www.ifma.org/resources/research/reports/pages/32.htm

[4] This survey shows that the mean maintenance cost of all types of facilities is $2.22 per SF (in 2007 dollars). This equates to $1.97 in 2002 dollars (comparable to those in the NIST paper).

TABLE 1.1 2002 Costs of Inadequate Interoperability by Stakeholder Group, by Life-Cycle Phase (totals in millions, unit costs in dollars) Based on Table ES-2 of NIST 04-867 Study

Stakeholder Group	Planning, Design, and Eng. Phase	Construction Phase	Operations and Maint. Phase	Total	Pct. of Total
Architects and Engineers	1,007.2	147.0	15.7	1,169.8	7.4%
Per square foot (SF)	0.89	0.13		1.02	
General Contractors	485.9	1,265.3	50.4	1,801.6	11.4%
Per SF	0.43	1.11			
Special Fabricators and Suppliers	442.4	1,762.2		2,204.6	13.9%
Per SF	0.39	1.55			
Owners and Operators	722.8	898.0	9,072.2	10,648.0	67.3%
Per SF	0.64	0.79	0.23	1.66	
Total	2,658.3	4,072.4	9,093.3	15,824.0	100.0%
Per SF	2.34	3.58	0.24	6.16	
Pct. of Total	16.8%	25.7%	57.5%	100.0%	

Note: Sums may not add to totals due to independent rounding.

TABLE 1.2 2002 Costs of Inadequate Interoperability by Cost Category by Stakeholder Phase (totals in millions) Based on Table ES-3 of NIST 04-867 Study

Cost Category	Avoidance Costs	Mitigation Costs	Delay Costs	Total	Pct. of Total
Architects and Engineers	485.3	684.5	—	1,169.8	7.4%
General Contractors	1,095.4	693.3	13.0	1,801.7	11.4%
Special Fabricators and Suppliers	1,908.4	296.1	—	2,204.5	13.9%
Owners and Operators	3,120.0	6,028.2	1,499.8	10,648.0	67.3%
Total	6,609.1	7,702.0	1,512.8	15,824.0	100.0%
Pct. of Total	41.8%	48.7%	9.6%	100.0%	

Note: Sums may not add to totals due to independent rounding.

HOW BIM FM INTEGRATION CAN ADDRESS CURRENT PROBLEMS

The short answer to the current problems previously described is: integration of data systems over the life cycle of a facility. The data needed to support a given phase of the life cycle needs to be entered just once in the level of

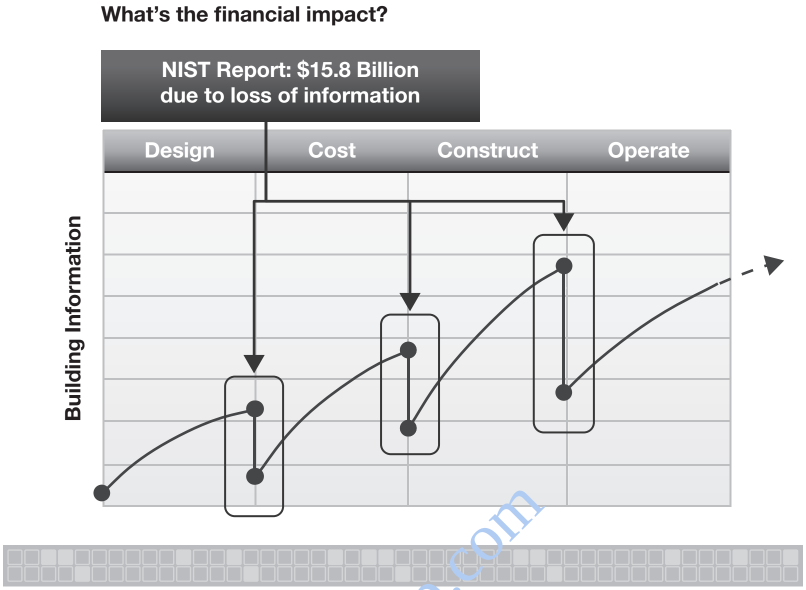

FIGURE 1.3 Loss of value as information is lost and reentered from phase to phase of the building life cycle (adopted from NIST report)
Courtesy FM:Systems

detail and accuracy that is available at that time. After that point, additional information is added as needed and at the appropriate level of detail. By the time commissioning of the building is completed, the data needed for O&M should be available for use in an accurate and usable form. This description of an ideal approach ignores many of the realities that make it difficult to achieve this goal. However, these details are covered in this book, and the reader will find that there are good solutions to this integration problem that should improve over time.

NEED FOR GRAPHICS AND DATA VARIES OVER THE LIFE CYCLE

Figure 1.4 illustrates the idea that the need for graphics is highest during the design phase and the need for detailed data is least. During conceptual design, BIM model creation systems are used to visualize the shapes, spaces, and generic objects (equipment, windows, systems, etc.). As the project progresses from conceptual to detail design, engineering analysis of various types requires more data about the materials, spaces, equipment, and so on that will be used in the building. During construction, even greater data and level of detail for cost estimation, procurement, coordination, constructability, and installation are needed. Finally, as the equipment

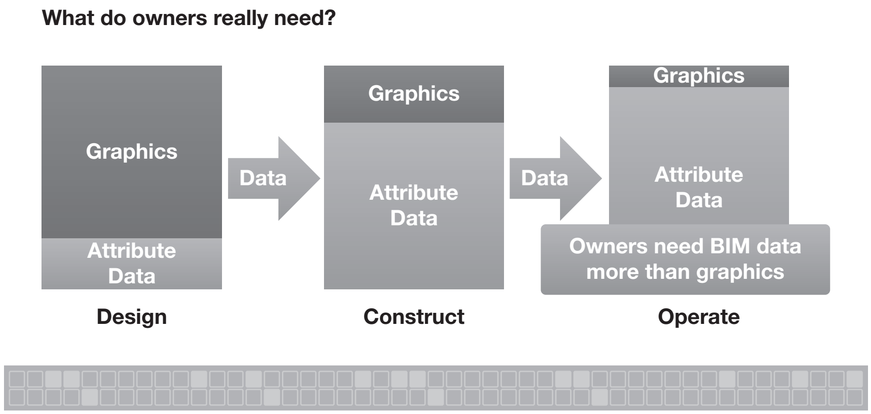

FIGURE 1.4 Mix of graphics and data changes over the facility life cycle.
Courtesy FM:Systems

is installed and systems are tested, the final information about these elements of the project become available and need to be entered into the system. One method of collecting these data is shown in Figure 1.5, where an iPad is being used to view a selected location (see left-hand menu that shows the Mechanical Room CB1021 is selected at the top with its properties shown on the right side). The user can then add a document, an attribute, or create an issue for the selected space (location). Similar properties are edited for assets and equipment.

FIGURE 1.5 Shows an iPad being used to enter equipment information after installation.
Courtesy EcoDomus

NEED FOR INTEROPERABILITY BETWEEN SYSTEMS

Clearly, all of the data is not entered into one model or one system. This therefore requires the interoperability of systems so that data can be communicated from upstream systems for downstream use. During operations and maintenance the FM data as well as the graphic data needed for FM use must be updated to reflect the changes. Once again, interoperability is the key. We will find that there are multiple approaches to achieving this flow of data, including use of open standards such as the Construction Operations Building information exchange (COBie) and proprietary approaches that integrate directly to specific BIM, CAFM, and CMMS systems. Figure 1.6 illustrates the data flows that need to be supported. This diagram shows alternative approaches to integration. In this figure, the FM Software platform can be any system used by facility managers that requires building data such as CMMS, CAFM, BAS, and so on.

One integration option is for users to develop a spreadsheet to capture the equipment and related data needed for FM and then either enter this directly into a CMMS system via an import mechanism. This approach may appear to be easier and faster to implement on small projects, but it lacks the formal structure

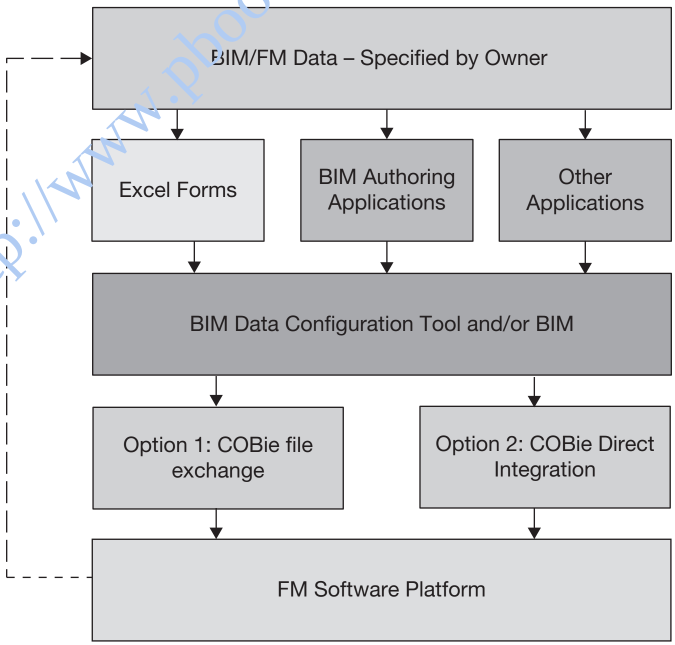

FIGURE 1.6 Alternative data paths to integrate BIM with FM.
Source: GSA BIM for FM Guidelines

of other approaches and has a higher error rate because there is no validation of the data being entered.

A second option is to use COBie, which is an open standard supported by the buildingSMART alliance. This standard specifies how all types of building and equipment data can be captured and what naming standards are appropriate for each kind of data (e.g., OmniClass codes for equipment). Using this option does not require integration with BIM as the COBie data can be imported into a CMMS program. But this option would not, for example, provide graphic data to show where equipment was located.

A third option is to take advantage of proprietary links between BIM modeling systems and FM support systems to create two-way links between these systems. EcoDomus is such a system and is being used to support facility managers who desire graphic views integrated with FM data (see Figure 1.7).

A fourth option is to directly integrate a CMMS system with a BIM modeling system using the BIM application programming interface (API). This provides an effective integration of both systems where graphics data is updated in BIM and FM data is entered into COBie and/or directly into the CMMS system. Another option is

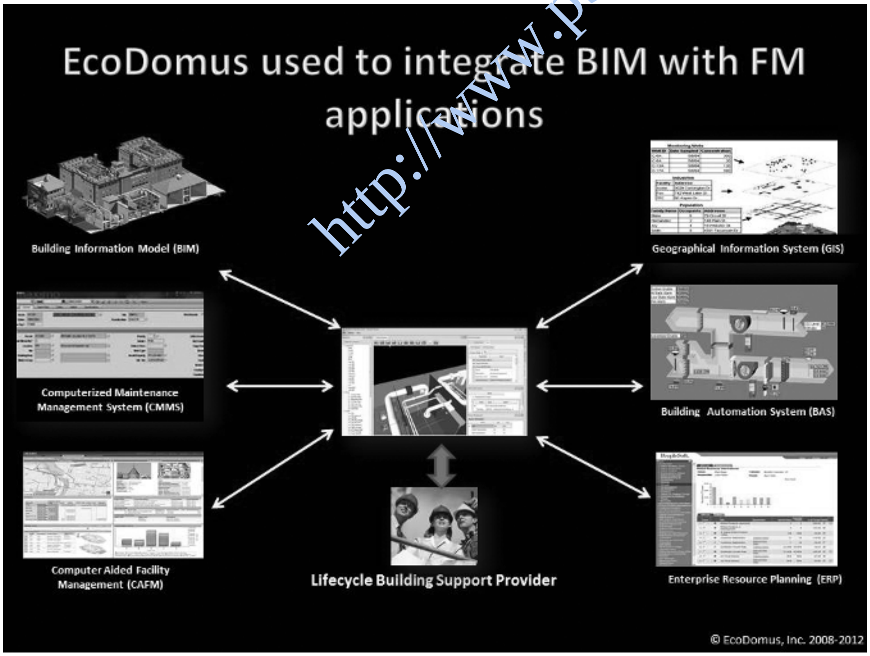

FIGURE 1.7 Example of graphic integration with FM data relating to a work order. Courtesy EcoDomus

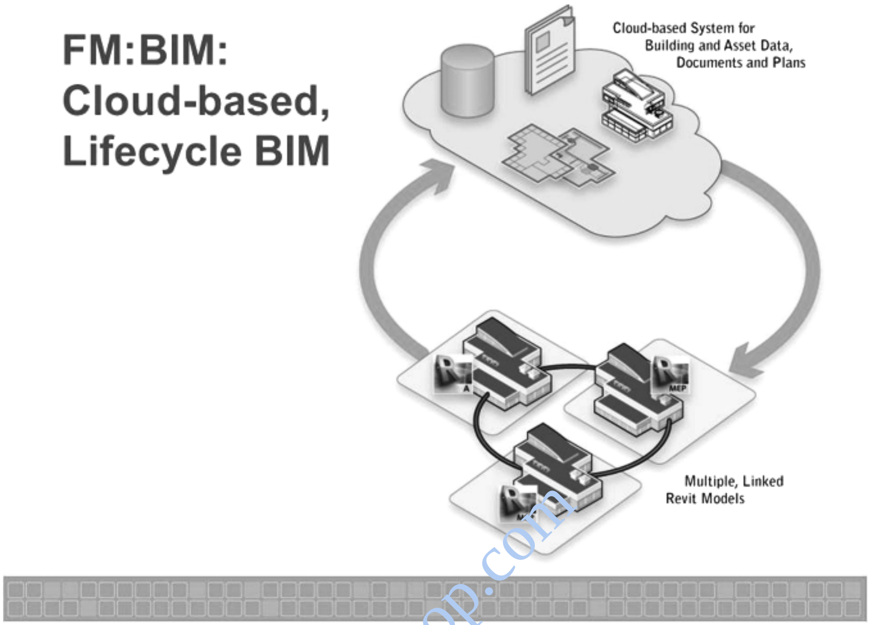

FIGURE 1.8 Direct integration of BIM and CMMS systems supported by cloud-based servers and accessed using a browser.
Courtesy FM:Systems

to support the data content on cloud-based servers that can be accessed at any location using a browser (see Figure 1.8).

OWNER BENEFITS OF BIM FM INTEGRATION

Streamlines Handover and More Effective Use of Data

A key benefit of integrating BIM with FM is that key data regarding spaces, equipment types, systems, finishes, zones, and so on can be captured from BIM and does not have to be reentered into a downstream FM system. For example, a COBie file can be extracted from the BIM model and then imported into a CMMS system. This avoids data entry cost, and generates higher-quality data. Then, as a detailed construction model is developed to document the as-built condition, additional information about equipment assemblies, ductwork, piping, electrical systems, and so on can be added to the model. This data will also be incorporated in the CMMS system, either via a COBie import or through direct integration with BIM. Finally, as equipment is installed, the equipment serial numbers can be recorded and entered into the COBie data. The result is a fully populated FM system that can be used when the building is commissioned. The

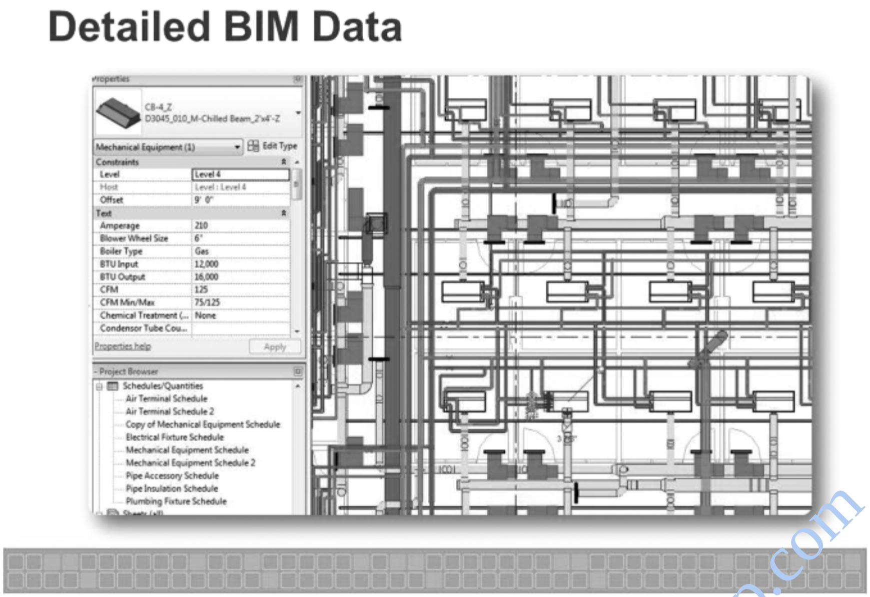

FIGURE 1.9 Shows a BIM model view of air-handling systems.
Courtesy FM:Systems

benefits to FM staff that help them understand how to operate and maintain the building are significant. Several of the case studies included in this book (see Chapter 6) illustrate this benefit and describe the processes that were used to achieve it. In Figure 1.9 we see a detailed BIM model of the systems in a building. This information can then be used with equipment data to plan maintenance after it has been linked to CMMS (see Figure 1.10).

Benefits during the Life of the Building

There are very significant cost benefits that should result from an integrated system providing accurate and complete information, including the following:

- Improved workforce efficiency because of the availability of better information when it is needed (in the office or field) rather than requiring FM staff to spend time looking up information on drawings, equipment documents, and other paper records.
- Reduced cost of utilities (energy and water) because of improved maintenance data that support better preventive maintenance planning and procedures. Building mechanical equipment will operate much more efficiently when properly maintained.

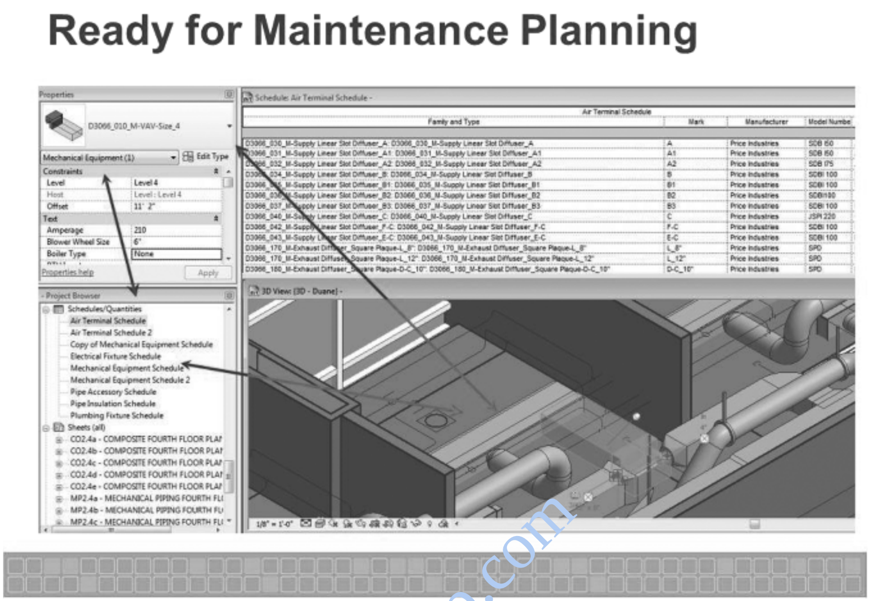

FIGURE 1.10 That same system data is now linked to equipment data in CMMS and can be used for maintenance planning.
Courtesy FM:Systems

- Reduction in equipment failures that cause emergency repairs and impact tenants.
- Improved inventory management of parts and supplies and better tracking of asset and equipment histories.
- Longer equipment lives supported by more extensive use of PM rather than breakdown maintenance. This reduces the cost of equipment replacement in the same way that proper auto maintenance extends an auto's life and provides more reliable service.[5]

These benefits all contribute to lowering facility total cost of ownership (TCO) and providing better customer service.

[5] The following information was reported by Jim Whittaker, president of Facility Engineering Associates, P.C. (FEA). A government agency that manages and operates facilities across the United States has 578 buildings of various types on the West Coast with an estimated area of 7 million square feet and a current replacement value (CRV) of $2.5 billion ($366/SF). By automating and generating good preventive maintenance programs and using CMMS to manage and track performance they were able to optimize their capital asset replacement decisions and extend asset/equipment useful life (EUL) by an average of 9.8 years over an average industry EUL value of 18.6 years (a remarkable increase of 53 percent). This extension applies to roughly 60 percent of the total asset value. Thus, extending the life of these assets represents an estimated ownership savings of $28.4 million per year or about $4.09/SF/yr or 1.12 percent of the CRV per year, a very impressive result.

It should be noted that the case histories in this book were not able to verify all these benefits because no project had used their integrated system for sufficient time to measure the ongoing benefits previously described. Thus, they remain reasonable but not yet substantiated by these case studies.

Integrated System Can Be Used to Plan Enhancements to Building

Buildings are continually changing; spaces are used for different functions, equipment is replaced, systems are modified, and so on. If the BIM FM system is kept up to date as these changes occur, it can serve as an accurate record of current conditions. FM staff will not need to search through drawings and other documents or break through walls or ceilings to determine actual conditions. By training the FM staff to maintain the system as conditions change, much better planning data is available and better decisions can be made. The cost of renovation projects will also be reduced by reducing the uncertainty that contractors must deal with when bidding on projects. Thus, the investment in BIM FM integration can provide benefits over the entire life of the facility.

Calculating ROI in BIM FM Integration

Making some reasonable and conservative estimates and combining these with data from the 2009 IFMA Survey of Maintenance Data, it is possible to calculate a rough return on the investment in the effort to collect the data needed for BIM FM integration. The significant advantages identified above can then be quantified and put in some perspective.

1. Base cost estimates on a typical office headquarters with 400,000 gross SF with 346,620 rentable SF (ratio of 1.154 GSF/RSF) with a useful life of 25 years. This building type was chosen because it has by far the largest number of responses in the IFMA survey cited above (431 out of 1,419 or 30 percent) and thus represents the most reliable data.
2. Initial costs to create integrated system:
   This includes the investment in systems, data collection and verification, training, and related expenses needed to support integrated BIM FM: roughly $100,000 (based on personal interviews with industry professionals).
3. Ongoing costs to maintain integrated system with updated information to reflect changes to building and its equipment: 1 FTE at $125,000/yr (fully burdened) working 25 percent of time on this activity: $31,250 per year. This percentage is an average over the year and will vary from 0 to 100 percent, depending on the number of changes that need to be entered.

4. Initial savings resulting from less labor effort required to gather the information about spaces and equipment. This data is available at the start of building occupancy because it has been captured during the design and construction process rather than after building turnover. This saving avoids the cost of two months for two FM people doing initial data gathering of building maintenance data: $41,667.
5. Ongoing savings from a number of sources:
   a. Assumed cost of O&M (from 2009 IFMA survey) mean value $1.98 per GSF (or $2.28 per rentable SF).
   b. O&M savings assuming that better access to accurate information will save 0.5 hours per work order, with 1,600 work orders per year and a total burdened labor rate of $50/hr. This yields a savings of $40,000 per year or $0.10 per GSF.
   c. Assumed utility costs (from 2009 IFMA survey) mean value $2.39 per GSF.
   d. Utility cost savings assuming that improved maintenance and performance of equipment will reduce energy costs of at least 3 percent. This yields a savings of $28,680 per year or $0.07 per GSF.
   e. The total costs for O&M and Utilities are $1,746,295 per year or $4.37 per GSF.
   f. The total savings per year is $68,680 or $0.17 per GSF, which represents 3.93 percent of these costs.
6. ROI calculations:
   a. Net initial investment is $100,000 reduced by $41,667 of initial savings, yielding a one-time investment of $58,333.
   b. Annual savings over the 25-year lifetime of the building is $68,680 − $31,250 = $37,430/yr.
   c. If we assume an owner interest rate of 6% on invested funds, the present value of $37,430 per year over 25 years is $478,481.
   d. This must be reduced by the initial cost to yield a net present value = $420,148.
   e. This can also be expressed as an internal ROI of 64 percent.
   f. The payback period for the net investment = $58,333 / $37,430 = 1.56 years.

Granted these are rough calculations, but they are based on the best data the author could obtain at this time. The reader is invited to calculate revised data based on his or her own data. The preceding results, however, exclude potential “soft” savings from better comfort (temperature and humidity controls), fewer breakdowns, better inventory control of spares, extension of life for equipment, and use of combined model for remodeling and upgrades. Thus, the results should be conservative. Even if the calculated result is off by a factor of 4, which is quite unlikely, it warrants adoption of BIM FM. There is little risk on the downside (except from lack of knowledge) and considerable room for real benefits. Clearly, this is an investment where understanding what is desired and having a clear plan to achieve these results are critical requirements.