

BIM for Owners and Facility Managers

4.0 EXECUTIVE SUMMARY

Owners can realize significant benefits on projects by using BIM processes and tools to streamline the delivery of higher quality and better performing buildings. BIM facilitates collaboration between project participants, reducing errors and field changes and leading to a more efficient and reliable delivery process that reduces project time and cost. There are many potential areas for BIM contributions. Owners can use a building information model to:

- **Increase building performance** through BIM-based energy and lighting design and analysis to improve overall building performance
- **Reduce the financial risk** associated with the project using the BIM model to obtain earlier and more reliable cost estimates and improved collaboration of the project team
- **Shorten project schedule** from approval to completion by using building models to coordinate and prefabricate design with reduced field labor time

- **Obtain reliable and accurate cost estimates** through automatic quantity takeoff from the building model, providing feedback earlier in a project when decisions will have the greatest impact
- **Assure program compliance** through ongoing analysis of the building model against owner and local code requirements
- **Optimize facility management and maintenance** by exporting relevant as-built building and equipment information to start the systems that will be used over the lifecycle of the facility

These benefits are available to all types of owners on almost all types of projects, however, it is clearly the case that owners have yet to realize all of the benefits associated with BIM or employ all of the tools and processes discussed in this book. Significant changes in the delivery process, selection of service providers, and approach to projects are necessary to fully realize BIM's benefits. Today, owners are rewriting contract language, specifications, and project requirements to incorporate the use of BIM-based processes and technologies into their projects as much as possible. Most owners that have initiated and/or participated in BIM efforts are reaping advantages in the marketplace through the delivery of higher value facilities and reduced operational costs. In concert with these changes, some owners are actively leading efforts to implement BIM tools on their projects by facilitating and supporting BIM education and research.

4.1 INTRODUCTION: WHY OWNERS SHOULD CARE ABOUT BIM

Lean processes and digital modeling have revolutionized the manufacturing and aerospace industries. Early adopters of these production processes and tools, such as Toyota and Boeing, have achieved manufacturing efficiencies and commercial successes (Laurenzo 2005). Late adopters were forced to catch up in order to compete; and although they may not have encountered the technical hurdles experienced by early adopters, they still faced significant changes to their work processes.

The AEC industry is facing a similar revolution, requiring both process changes and a paradigm shift from 2D-based documentation and staged delivery processes to a digital prototype and collaborative workflow. The foundation of BIM is one or more coordinated and information-rich building models with capabilities for virtual prototyping, analysis, and virtual construction of a project. These tools broadly enhance today's CAD capabilities with an improved ability to link design information with business processes, such as estimating,

sales forecasts, and operations. These tools support a collaborative rather than fragmented approach to project procurement. This collaboration builds trust and common goals that serve the owner rather than competitive relationships where each team member strives to maximize their individual goals. In contrast, with drawing-based processes, analyses must be done independently of the building design information, often requiring duplicate, tedious, and error-prone data entry. The result is loss of value in information assets across phases, many more opportunities for errors and omissions, and increased effort to produce accurate project information, as the conceptual diagram in Figure 4–1 shows. Consequently, such analyses can be out of sync with design information and lead to errors. With BIM-based processes, the owner can potentially realize a greater return on his or her investment as a result of the improved integrated design process, which increases the value of project information in each phase and allows greater efficiency for the project team. Simultaneously, owners can reap dividends in project quality, cost, and future operation of the facility.

The new Integrated Project Delivery (IPD) approach to procuring construction projects (introduced in Chapter 1, Section 1.2.4) aims to achieve close collaboration among all members of a project team. BIM has proved to

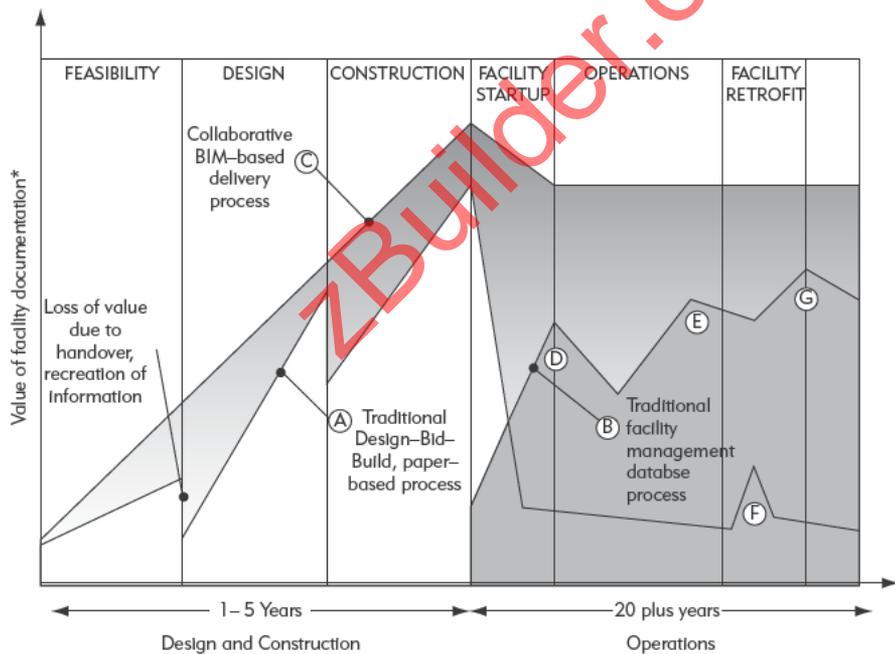


FIGURE 4-1

(A) Traditional single-stage drawing-based deliverables, (B) traditional facility management database system, (C) BIM-based deliverables throughout the project delivery and operation process, (D) setup of facility management (FM) database, (E) integration of FM with back-office systems, (F) use of "as-built" drawings for retrofit, and (G) update of FM database.

* slope of line communicates effort to produce and maintain information

- D) Setup of facility management database
- E) Integration of FM with back-office systems
- F) Use of 'as-built' drawings for retrofit
- G) Update of facility management database

be a key enabling technology for IPD teams. The owner's role in initiating and sustaining IPD projects is central and critical, and starts with the first project contract, sometimes called the "Integrated Agreement for Lean Project Delivery" (IFOA) (Mauck et al. 2009). There are also standard IPD contracts published by the AIA and ConsensusDocs (ConsensusDocs 300 series). An excellent discussion of how IPD can support owners' needs with an analysis of contractual issues can be found in a paper by a team of lawyers who have considerable experience with this form of project procurement (Thomsen et al. 2009).

The IPD contract usually defines the BIM software tools the various team members will use, and the information-sharing server solutions the project will support for the benefit of the project as a whole. Under IPD contracts, the owner plays an active role through the life of the project, taking part in decision-making at all levels. BIM tools are essential for owners to understand the intent and the considerations of the designers and builders who make up the IPD team. IPD is discussed further in Chapters 5, 6, and 8 (Sections 5.2.1, 6.11, and 8.3, and are described in detail in the Sutter Medical Center case study in Chapter 9.

This chapter discusses how owners can use BIM to manage project risk, improve project quality, and deliver value to their businesses. It also shows how facility managers can use BIM to better manage their facilities. Owners here are the organizations that initiate and finance building projects. They make strategic decisions in the facility delivery process through the selection of service providers and the type of delivery processes they use. These decisions ultimately control the scope and effectiveness of BIM on a project.

The chapter begins with a discussion of BIM applications for all types of building owners and facility managers. Section 4.3 provides a guide to BIM tools that are suitable or better oriented for owners. Most of the BIM tools available today are targeted toward service providers, such as architects, engineers, contractors, and fabricators; they are not specifically targeted for owners. Other tools are discussed in Chapters 5, 6, and 7, and references are provided for those sections. Section 4.4 discusses the owner's building information model and how the owner's perspective of it and the scope and level of detail may differ from those discussed in subsequent chapters.

Owners play a significant education and leadership role in the building industry. They are the purchasers and often the operators of the AEC industry's products. Section 4.5 discusses different ways for owners to implement BIM applications on their projects, including prequalification of service providers, education and training seminars, guidelines for developing contractual requirements, and changing their internal processes. Section 4.6 follows with a discussion of the risks and the process and technology barriers associated with

BIM implementation. The chapter concludes with guidelines for successful implementation.

4.2 BIM APPLICATION AREAS FOR OWNERS

Traditionally, owners have not been agents of change within the building industry. They have long been resigned to typical construction project problems, such as cost overruns, schedule delays, and quality issues (Jackson 2002). Many owners view construction as a relatively small capital expenditure compared to the lifecycle costs or other operational costs that accrue over time. Changing marketplace conditions, however, are forcing owners to rethink their views and place greater emphasis on the building delivery process and its impact on their business (Geertsema et al. 2003; Gaddie 2003).

The firms that provide services to owners (AEC professionals) often point to the short-sightedness of owners and the frequent owner-requested changes that ultimately impact design quality, construction cost, and schedule.

Because of the considerable potential impact that BIM can have on these problems, the owner is in the position to benefit most from its use. Thus, it is critical that owners of all types understand how BIM applications can enable competitive advantages and allow their organizations to better respond to market demands and yield a better return on their capital investments. In those instances in which service providers are leading the BIM implementation—seeking their own competitive advantage—educated owners can better leverage the expertise and know-how of their design and construction team.

In the following sections, we provide an overview of drivers that are motivating all types of owners to adopt BIM technologies, and we describe the different types of BIM applications available today. These drivers are:

- Design assessment early and often
- Complexity of facilities
- Time to market
- Cost reliability and management
- Product quality, in terms of leakages, malfunctions, unwarranted maintenance
- Sustainability
- Asset management

Table 4–1 summarizes the BIM applications reviewed in this chapter from the owner's perspective and the respective benefits associated with those

Table 4–1 Summary of BIM Application Areas and Potential Benefits to All Owners, Owner-Operators, and Owner-Developers; and a Cross-Reference to Case Studies Presented in Chapter 9

Book Section	Specific BIM Application Areas for Owner (referenced in this chapter)	Market Driver	Benefits to All Owners	Relevant Case Study (CS) or Reference
Chapter 5: Designers and Engineers	Space planning and program compliance	Cost management; marketplace complexity	Ensure project requirements are met	Helsinki Music Hall
	Energy (environmental) analysis	Sustainability	Improve sustainability and energy efficiencies	Marriott Hotel Renovation Helsinki Music Hall
	Design configuration/ scenario planning	Cost management; complexity of building infrastructure	Design quality communication	Aviva Stadium Coast Guard Facility Planning
	Building system analysis/simulation	Sustainability	Building performance and quality	Marriott Hotel Renovation Helsinki Music Hall 100 11th Ave., New York City
	Design communication/ review	Marketplace complexity and language barriers	Communication	All case studies
Chapters 5 and 6: Designers, Engineers, Contractors	Quantity takeoff and cost estimation	Cost management	More reliable and earlier estimates during the design process	Hillwood Commercial Project, Dallas Sutter Medical Center
	Design coordination (clash detection)	Cost management and infrastructure complexity	Reduce field errors and reduce construction costs	Sutter Medical Center One Island East Office Tower, Hong Kong
Chapters 6 and 7: Contractors and Fabricators	Schedule simulation/4D	Time to market, labor shortages, and language barriers	Communicate schedule visually	One Island East Office Tower Crusell Bridge, Finland
	Project controls	Time to market	Track project activities	Sutter Medical Center
	Prefabrication	Time to market	Reduce onsite labor and improve design quality	Sutter Medical Center 100 11th Ave., New York City Aviva Stadium, Dublin Crusell Bridge, Finland
Chapter 4: Owners	Pro forma analysis	Cost management	Improve cost reliability	Hillwood Commercial Project, Dallas
	Operation simulation	Sustainability/Cost management	Building performance and maintainability	Sutter Medical Center Helsinki Music Hall
	Commissioning and asset management	Asset management	Facility and asset management	Coast Guard Facility Planning, various locations Maryland General Hospital, Philadelphia

applications. Many of the applications referenced in this chapter are elaborated on in greater detail in Chapters 5, 6, and 7, and in the case studies presented in Chapter 9.

4.2.1 Design Assessment

Owners must be able to manage and evaluate the scope of the design against their own requirements at every phase of a project. During conceptual design, this often involves spatial analysis. Later on, this involves analyses for evaluating whether the design will meet its functional needs. Today, this is a manual process, and owners rely on designers to walk through the project with drawings, images, or rendered animations. Requirements often change, however, and even with clear requirements, it can be difficult for an owner to ensure that all requirements have been met.

Additionally, an ever increasing proportion of projects involve either the retrofit of existing facilities or building in an urban setting. These projects often impact the surrounding community or users of the current facility. Seeking input from all project stakeholders is difficult when they cannot adequately interpret and understand the project drawings and schedule. Owners can work with their design team to use a building information model to:

Integrate development of programmatic requirements

During the programmatic and feasibility phase, owners, working with their consultants, develop programs and requirements for projects. They often perform this process with little feedback with respect to feasibility and costs of various programmatic features or project requirements. One potential tool to facilitate this process is BIMStorm, an environment and process developed by Onuma Systems, which allows owners and multiple participants and stakeholders to conceptualize a project, solicit input from multiple sources, and assess in real time various design options from cost, time, and sustainability perspectives. Figure 4–2, for example, shows one of these sessions. The team develops a conceptual building model to develop in real time a realistic program.

Improve program compliance through BIM spatial analyses

Owners such as the United States Coast Guard are able to do rapid spatial analyses with BIM authoring tools (See Coast Guard Facility Planning case study in Chapter 9). The case study includes figures demonstrating how a building model can communicate in real time both spatially and in data form, to check compliance with requirements. Different colors are automatically assigned to rooms based on their dimensions and function.

FIGURE 4-2

A team working remotely with other teams via the Web to quickly develop and assess design alternatives using the Onuma System (OS) during a BIMStorm event. OS allows participants to provide input, develop alternatives, and assess a proposed design from multiple perspectives to develop more realistic programmatic requirements that align with the owner's budget and overall project requirements.

Image provided courtesy of Onuma Systems and the Computer Integrated Construction Research Program at Penn State.



In some cases, the color-coding can alert designers or owners of rooms that exceed or don't meet existing requirements. This visual feedback is invaluable during conceptual and schematic design. Thus, the owner can better ensure that the requirements of their organization are met and that operational efficiencies of the program are realized.

Receive more valuable input from project stakeholders through visual simulation

Owners often need adequate feedback from project stakeholders, who either have little time or struggle with understanding the information provided about a project. Figure 4-3 is a snapshot of judges reviewing their planned courtroom. Figure 4-7 shows a 4D snapshot of all floors of a hospital to communicate the sequence of construction for each department and get feedback on how it will impact hospital operations. In both projects, the building information model and rapid comparison of scenarios greatly enhanced the review process. The traditional use of real-time and highly rendered walkthrough technologies are one-time events, whereas the BIM and 4D tools make what-if design explorations far easier and more viable economically.

Rapidly reconfigure and explore design scenarios

Real-time configuration, however, is possible either in the model generation tool or a specialized configuration tool. Figure 4-4 shows an



FIGURE 4-3

Snapshot showing the owner (GSA) and judges in a Virtual Reality Cave environment while interactively reviewing the design.

Image provided courtesy of Walt Disney Imagineering.

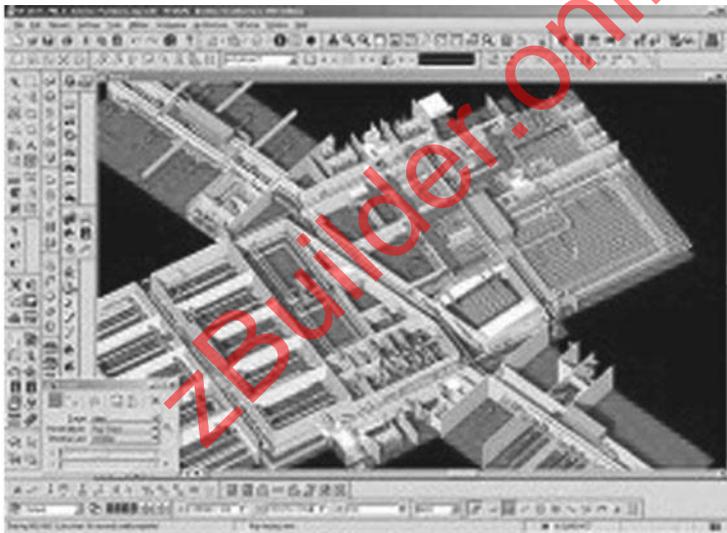


FIGURE 4-4

Example of BIM space modeling by Jacobs Facilities, where they used spatial information to check the design against program requirements and to evaluate such things as natural lighting and energy efficiencies during the conceptual design process.

Image provided courtesy of Jacobs.



example from the Jacobs Facilities project, where BIM was used to quickly evaluate scenarios and to analyze requirements, needs, budget, and owner feedback (McDuffie 2007).

Another approach specifically targeted to help owners rapidly assess the feasibility of alternative building designs is provided by the DProfiler system developed by Beck Technology. This system provides cost, pro forma, and energy analyses based on conceptual designs. It is discussed in detail in Section 2.6.7 and in further examples in this chapter.

Simulate facility operations

Owners may need additional types of simulations to assess the design quality beyond walkthroughs or visual simulations. These may include crowd behavior or emergency evacuation scenarios. Figure 4–8 shows an example crowd simulation for a typical day at a metro station with related analysis. The simulations used the building information model as a starting point for generating these scenarios. Such simulations are labor intensive and involve the use of specialized tools and services. For facilities where such performance requirements are critical, however, the initial investment in a building information model can pay off due to the more accurate 3D input that these specialized tools require.

4.2.2 Complexity of Building Infrastructure and Building Environment

Modern buildings and facilities are complex in terms of the physical infrastructure and the organizational, financial, and legal structures used to deliver them. Complicated building codes, statutory issues, and liability issues are now common in all building markets and are often a bottleneck or a significant hurdle for project teams. Often, owners must coordinate the design and approval efforts simultaneously. Meanwhile, facility infrastructures have grown increasingly complex. Traditional MEP systems are being integrated with data/telecom, building sensors or meters, and in some cases sophisticated manufacturing or electrical equipment.

BIM tools and processes can support owners' efforts to coordinate the increasingly complex building infrastructure and regulatory process by:

Coordinating infrastructure through fully integrated 3D models of MEP, architectural, and structural systems

A building information model enables virtual coordination of a building's infrastructure across all disciplines. The owner of a facility can include its own representatives from its maintenance and operations staff to provide input and review of the model. Rework due to design flaws can

potentially be avoided. The Crusell Bridge, Sutter Medical Center, and the Helsinki Music Hall projects demonstrate how an owner can work with a construction team to coordinate complex concrete and MEP systems using digital 3D models.

Producing higher-quality and maintainable infrastructure through interactive review of coordinated models

Many owners need to go beyond typical MEP coordination to ensure that the MEP, data/telecom, and equipment are accessible and maintainable. This is particularly crucial for companies that depend heavily on these systems, such as biotech and technology companies, which demand reliable 24/7 service. Interactive review of the model allows owners to virtually access and simulate maintenance procedures.

Preventing litigation through collaborative creation and sign-off of building information models

Today, many projects invoke litigation to resolve payment issues due to changes. These issues include: designers citing owner-initiated changes; owners arguing that designers did not meet contractual requirements; and contractors arguing about scope of work and lack of information or inaccurate project documentation. Processes that center on a building model can mitigate such situations simply due to the level of accuracy and resolution necessary for creating a model; the collaborative effort of creating the model often leads to better accountability among project participants.

4.2.3 Sustainability

The green building trend is leading many owners to consider the energy efficiency of their facilities and the overall environmental impact of their projects. Sustainable building is good business practice and can lead to greater marketability of a facility. Building models provide several advantages over traditional 2D models due to the richness of object information needed to perform energy or other environmental analyses. Specific BIM analysis tools are discussed in detail in Chapters 2 and 5. From the owner's perspective, BIM processes can help:

Reduce energy consumption through energy analysis

On average, energy accounts for \$1.50 to \$2.00 per square foot of operational costs (Hodges and Elvey 2005). For a 50,000 square foot facility, this amounts to \$75,000 to \$100,000 annually. Investment in an energy-saving building system, such as enhanced insulation, reduces energy consumption by 10 percent and translates to \$8,000 to \$10,000 annual savings. The breakeven point for an up-front investment of \$50,000

would occur by the sixth year of operation. The challenge when making such assessments is to compute the actual reduction in energy consumption achievable by any specific design. There are many tools for owners to evaluate the payoff and return on energy-saving investments, including lifecycle analysis, and these are discussed in Chapter 5. While these analysis tools do not absolutely require the use of a building information model for input, a model greatly facilitates their use. The Helsinki Music Hall case study in Chapter 9 demonstrates the kinds of energy conservation analyses that can be integrated using BIM tools.

Improve operational productivity with model creation and simulation tools

Sustainable design can greatly impact overall workplace productivity. Ninety-two percent of operating costs are spent on the people who work in the facility (Romm 1994). Studies suggest that day-lighting in retail and offices improves productivity and reduces absenteeism (Roodman and Lenssen 1995). BIM technologies provide owners with tools needed for assessing the appropriate tradeoffs when considering the use of day-lighting and the mitigation of glare and solar heat gain, as compared with project cost and overall project requirements. The Helsinki Music Hall case study compared different scenarios to maximize the potential benefits of different glazing systems.

Once the facility is complete, owners can use the building model and design data to monitor energy consumption and compare real-time use.

4.2.4 Cost Reliability and Management

Owners are often faced with cost overruns or unexpected costs that force them to either “value engineer,” go over budget, or cancel the project. Surveys of owners indicate that up to two-thirds of construction clients report cost overruns (Construction Clients Forum 1997; FMI/CMAA 2005, 2006). To mitigate the risk of overruns and unreliable estimates, owners and service providers add contingencies to estimates or a “budget set aside to cope with uncertainties during construction” (Touran 2003). Figure 4–5 shows a typical range of contingencies that owners and their service providers apply to estimates, which vary from 50 to 5 percent depending on the project phase. Unreliable estimates expose owners to significant risk and artificially increase all project costs.

The reliability of cost estimates is impacted by a number of factors, including market conditions that change over time, the time between estimate and execution, design changes, and quality issues (Jackson 2002). The accurate and computable nature of building information models provides a more reliable source for owners to perform quantity takeoff and estimating and

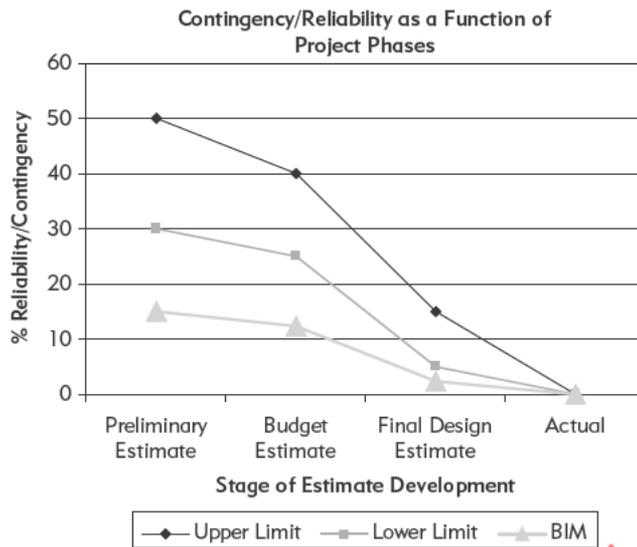
**FIGURE 4-5**

Chart showing the upper and lower limits that an owner typically adds to the contingency and reliability of an estimate over different phases of a project (data adapted from United States 1997; Munroe 2007; Oberlander and Trost 2001) and the potential targeted reliability improvements associated with BIM-based estimating.

provides faster cost feedback on design changes. This is important because the ability to influence cost is highest early in the process at the conceptual and feasibility phase, as shown in Figure 4-6. Estimators cite insufficient time, poor documentation, and communication breakdowns between project participants, specifically between owner and estimator, as the primary causes of poor estimates (Akintoye and Fitzgerald 2000).

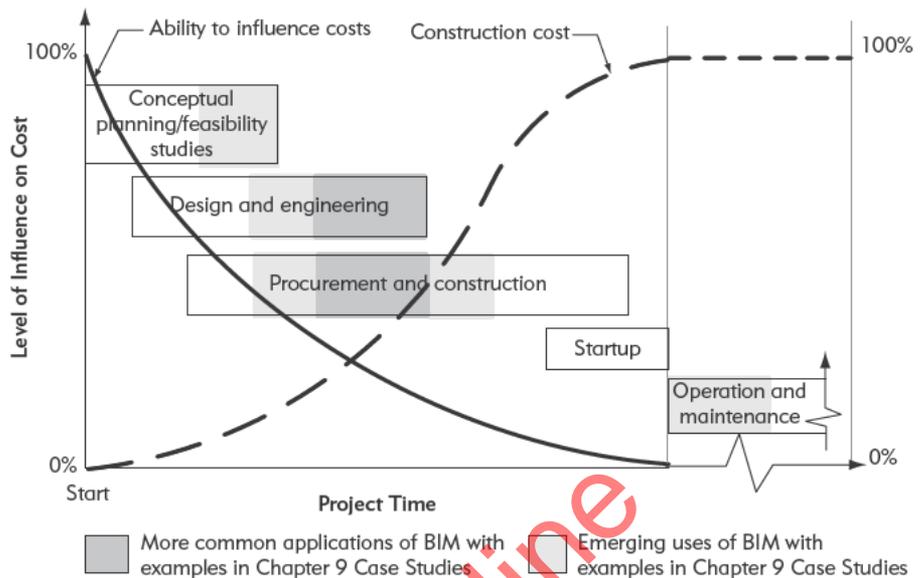
Today's use of BIM is typically limited to the late phase of design and engineering or early phases of construction. Use of BIM earlier in the design process will have greater influence on cost. Improving overall cost reliability is a key motivator for employing BIM-based cost estimating methods.

Owners can manage cost with BIM applications to provide:

More reliable estimates early in the process with conceptual BIM estimating

Estimates that use conceptual building information models consisting of components with historical cost information, productivity information, and other estimating information can provide owners with quick feedback on various design scenarios. Accurate estimates can be very valuable early in the project, particularly for assessing a project's predicted cash flow and procuring finance. The Hillwood Commercial project case study, discussed in Chapter 9, demonstrates how owners working with a service provider employing a conceptual BIM-based estimating tool called DProfiler are able to reduce overall contingency and reliability and ultimately save money by borrowing less.

FIGURE 4-6
Influence of overall project cost over the project lifecycle.



Faster, better-detailed, and more accurate estimates with BIM quantity takeoff tools

Both owners and estimators struggle with the ability to respond to design and requirement changes and understand the impact of those changes on the overall project budget and estimate. By linking the design model with the estimating processes, the project team can speed up the quantity takeoff and overall estimating process and get faster feedback on proposed design changes (see Chapters 5 and 6). For example, owners can automatically derive accurate quantities and in turn streamline and verify estimates of designers and subcontractors (Rundell 2006). The Hillwood Commercial project case study in Chapter 9 cites evidence that estimating with BIM early in design can result in a 92 percent time reduction to produce the estimate with only a 1 percent variance between the manual and BIM-based processes. In the One Island East Office Tower case study in Chapter 9, the owner was able to set a lower contingency in their budget as a result of the reliability and accuracy of the BIM-based estimate. In the Sutter Medical Center case study, the team performed model-based cost estimating every two to three weeks during design to ensure that the design was kept within the budget.

Owners, however, must realize that BIM-based takeoff and estimating is only a first step in the whole estimating process; it does not thoroughly address the issue of omissions. Additionally, the more accurate derivation

of components that BIM provides does not deal with specific site conditions or the complexity of the facility, which depend on the expertise of an estimator to quantify. BIM-based cost estimation strategically helps the experienced cost estimators but does not replace them.

4.2.5 Time to Market: Schedule Management

Time to market impacts all industries, and facility construction is often a bottleneck. Manufacturing organizations have well-defined time-to-market requirements, and must explore methods and technologies that enable them to deliver facilities faster, better, and cheaper. BIM provides owners and their project teams with tools to partially automate design, simulate operations, and employ offsite fabrication. These innovations—initially targeted toward manufacturing or process facilities—are now available to the general commercial facility industry and its service providers. The innovations provide owners with a variety of BIM applications to respond to the following time to market needs:

Reduce time to market through the use of parametric models

Long building cycles increase market risk. Projects that are financed in good economic times may reach the market in a downturn, greatly impacting the project's ROI (Return on Investment). BIM processes, such as BIM-based design and prefabrication, can greatly reduce the project duration, from project approval to facility completion. The component parametric nature of the BIM model makes design changes easier and the resulting updates of documentation automatic. The Flint Global V6 Engine Plant Expansion project was an excellent example of a parametric-based design used to support rapid scenario planning early in a project (it is described in the first edition of the *BIM Handbook*, Section 9.1). This large complex project was designed and built in 35 weeks, which is roughly half of what would have been required for a conventional design-build approach.

Reduce schedule duration with 3D coordination and prefabrication

All owners pay a cost for construction delays or lengthy projects, either in interest payments on loans, delayed rental income, or other income from sales of goods or products. In the Sutter Medical Center case study in Chapter 9, the owner was under a legal requirement to complete a new hospital that met earthquake standards by the end of 2012. The application of BIM to support early coordination, constructability analysis, and prefabrication led to improved design and field productivity, reduced field effort, and significant reductions in the overall construction schedule, which resulted in a confident forecast of on-time delivery.

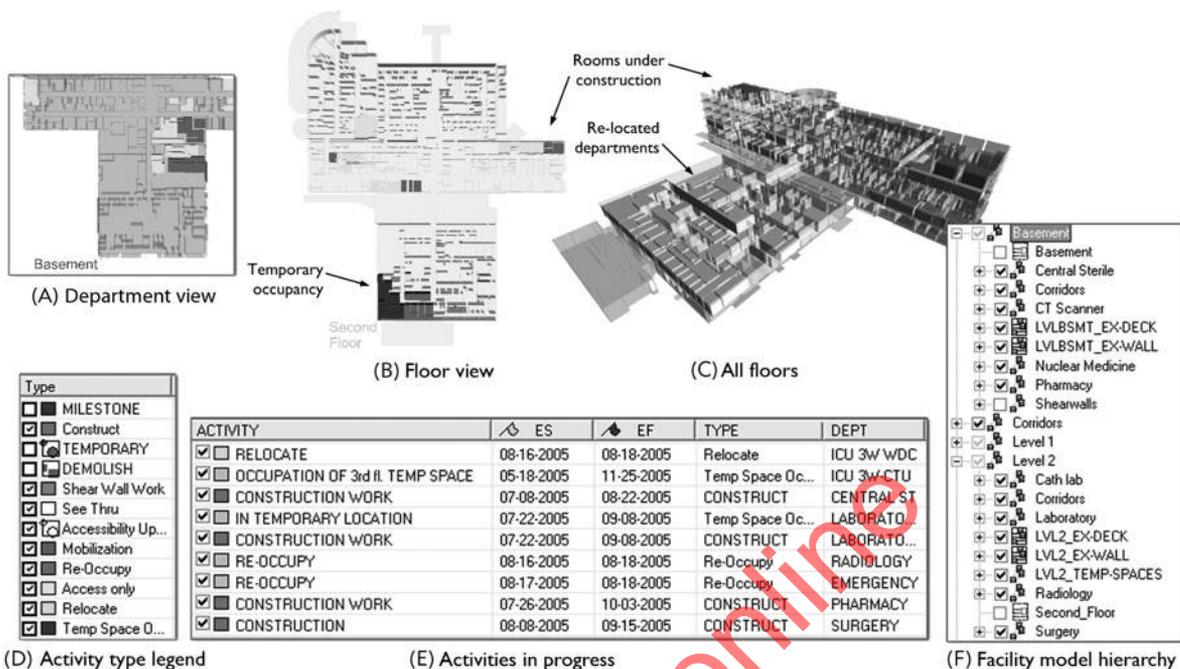


FIGURE 4-7 Views of a 4D model for a nine-floor hospital facility showing concurrent retrofit activities across departments and floors: (A) 4D view of a department; (B) 4D view of a floor; (C) 4D view of all floors; (D) activity type legend showing the types of activities the construction management team and owner communicated in the 4D model; (E) the activities in progress; and (F) the 4D hierarchy showing the organization by floor and department.

Image provided courtesy of URS.

Reduce schedule-related risk with BIM-based planning

Schedules are often impacted by activities involving high risk, dependencies, multiple organizations, or complex sequences of activities. These often occur in projects such as renovations of existing facilities, where construction must be coordinated with ongoing operations. For example, a construction manager representing the owner used 4D models (see Chapter 6 and Figure 4-7) to communicate a schedule to hospital staff and mitigate the impact of activities on their operations (Roe 2002).

Quickly respond to unforeseen field conditions with 4D-coordinated BIM models

Owners and their service providers often encounter unforeseen conditions that even the best digital models cannot predict. Teams using digital models are often in a better position to respond to unforeseen conditions and get back on schedule. For example, a retail project was slated to open before Thanksgiving for the holiday shopping season. Three months into

the project, unforeseen conditions forced the project to stop for three months. The contractor used a 4D model (see Chapter 6) to help plan for the recovery and open the facility on time (Roe 2002).

4.2.6 Facility and Information Asset Management

Every industry is now faced with understanding how to leverage information as an asset; and facility owners are no exception. Today, information is generated during each project phase and often reentered or produced during hand-offs between phases and organizations, as shown in Figure 4-1. At the end of most

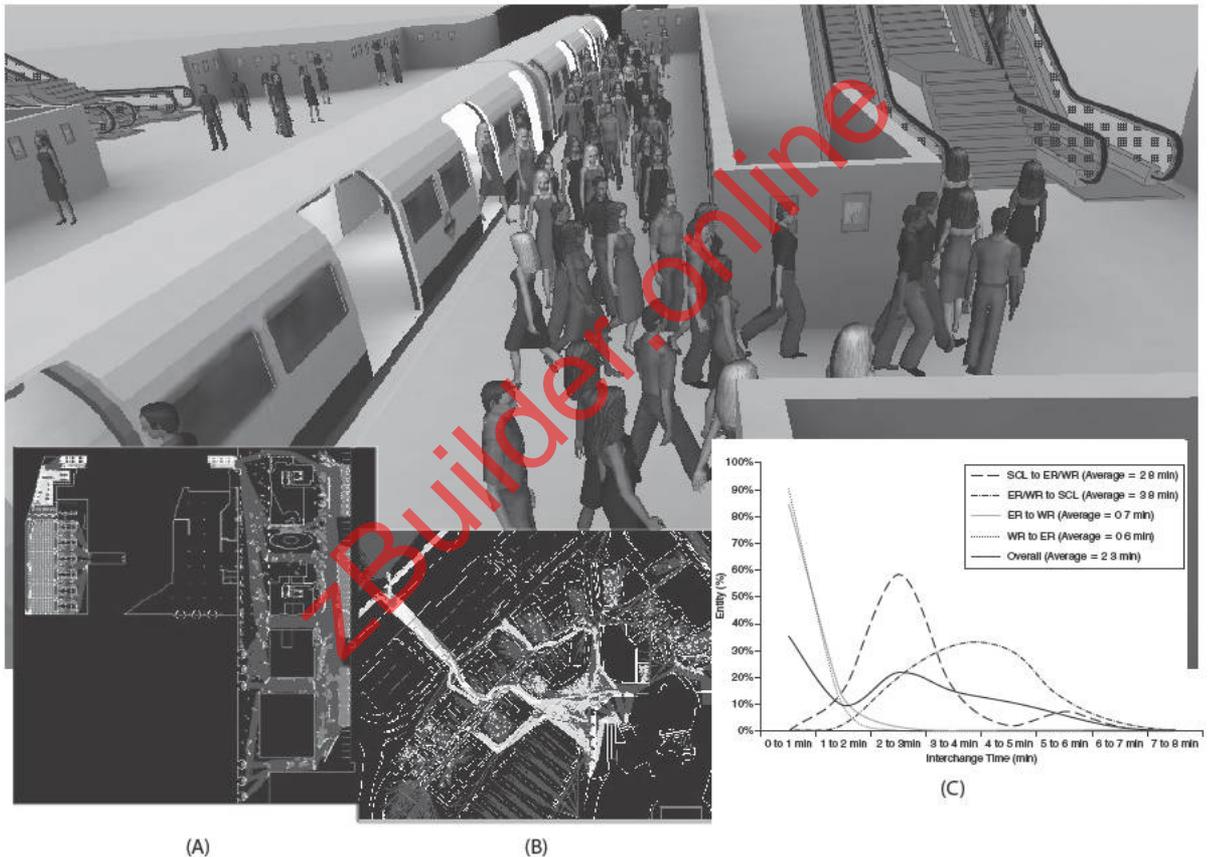


FIGURE 4-8 Examples of Legion Studio's visual and analytical outputs based on 2D and 3D building information data. The main 3D rendering shows a simulation of a metro station during a weekday morning peak. (A) A map of an airport uses color to show average speed, with red indicating slow movement and blue indicating free-flowing movement; (B) a map of a stadium with access routes and adjacent retail facilities showing mean density, with red and yellow indicating the locations of highest density; and (C) a graph comparing passenger interchange times between several origin-destination pairs. (See color insert for full color figure.)

projects, the value of this information drops precipitously, because it is typically not updated to reflect as-built conditions or in a form that is readily accessible or manageable. Figure 4–1 shows that a project involving collaborative creation and updating of a building model potentially will see fewer periods of duplicate information entry or information loss. Owners who view the total lifecycle ownership of their projects can use a building model strategically and effectively to:

Commission a building more efficiently

According to the Building Commissioning Association (see www.bcxa.org/), “Building commissioning provides documented confirmation that building systems function according to criteria set forth in the project documents to satisfy the owner’s operational needs.” The Maryland General Hospital case study (see Chapter 9) describes how the team used a building model, tablet PCs, and custom software to record equipment data and perform the commissioning activities.

Quickly populate a facility management database

In the Coast Guard Facility Planning case study, the team realized a 98 percent time savings by using building information models to populate and edit the facility management database. These savings are attributed to a reduction in labor needed to enter the spatial information.

Manage facility assets with BIM asset management tools

The United States Coast Guard is integrating BIM into its portfolio and asset management, as discussed in the Coast Guard Facility Planning case study. Blach Construction developed a BIM model for a school client to manage and maintain all of their MEP systems across their campuses (Figure 4–9). Another example is a 4D financial model shown in Figure 4–9.

Another example is a 4D financial model shown in Figure 4–10 that associates each building object or objects with a condition assessment over time. The owner can view the facility or facilities periodically to get a “big picture” view of its condition assessment.

Rapidly evaluate the impact of retrofit or maintenance work on the facility

Another example is the use of visual and intelligent models to help facility managers assess the impact of retrofit or maintenance work. For example, a BIM-based FM system was applied during maintenance work on the Sydney Opera House (Mitchell and Schevers 2005). The maintenance team used the model to visually assess which areas would be affected when power was cut to a specific room.

and Chapters 5 through 7 discuss the specific BIM design and construction technologies, such as model generation tools, energy analysis, 4D, and design coordination. Here, the discussion addresses specific tools targeted to owners.

4.3.1 BIM Estimating Tools

Owners use estimates to baseline their project cost and perform financial forecasting or pro forma analyses. Often, these estimates are created early in design before the team develops a fully detailed building model. Estimates are created using square foot or unit cost methods, by an owner representative or estimating consultant. The Hillwood case study in Chapter 9 discusses the use of DProfiler to use the building model to generate conceptual and pro forma estimates.

Some estimating software packages, such as U.S. Cost Success Estimator (U.S. Cost 2010), are designed specifically for owners. Microsoft® Excel, however, is the software most commonly used for estimating. In 2007, U.S. Cost provided their customers with functionality to extract quantity takeoff information from a building model created in Autodesk Revit®. Another product targeted to owners is Exactal's CostX® product (Exactal 2010), which imports building models and allows users to perform automatic and manual takeoffs. Chapter 6 provides a more detailed overview of BIM-based estimating tools.

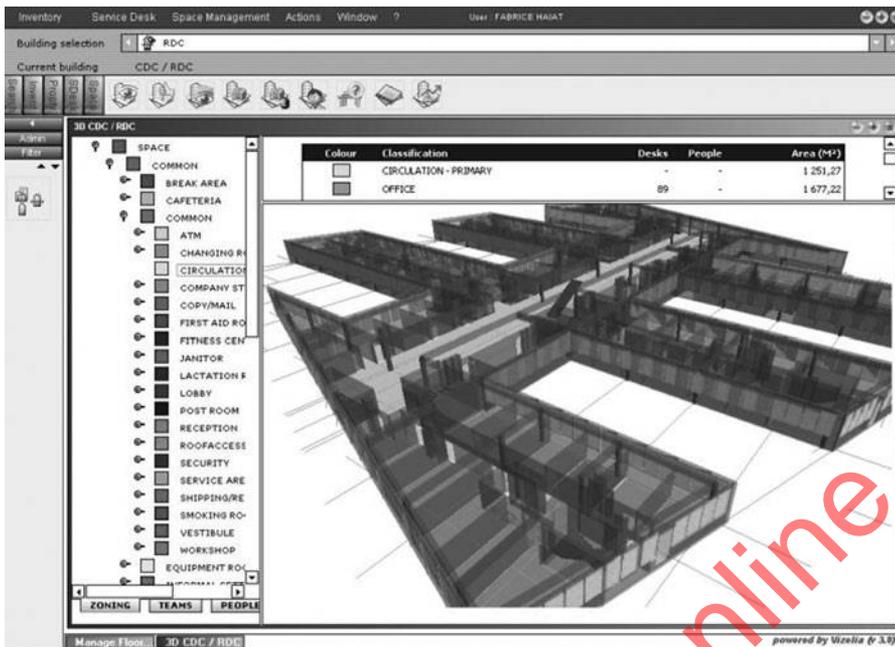
4.3.2 Facility and Asset Management Tools

Most existing facility management tools either rely on polygonal 2D information to represent spaces or numerical data entered in a spreadsheet. From most facility managers' perspectives, managing spaces and their related equipment and facility assets does not require 3D information; but 3D, component-based models can add value to facility management functions.

Building models provide significant benefits in the initial phase of entering facility information and interacting with that information. With BIM, owners can utilize "space" components that define space boundaries in 3D, thus greatly reducing the time needed to create the facility's database, since the traditional method involves manual space creation once the project is complete. The Coast Guard Facility Planning case study in Chapter 9 recorded a 98 percent reduction in time and effort to produce and update the facility management database by using a building information model.

Today, few tools exist that accept the input of BIM space components or other facility components representing fixed assets. Some of the tools that are currently available are:

- ActiveFacility (www.activefacility.com)
- ArchiFM (www.graphisoft.co.uk/products/archifm)

**FIGURE 4-11**

Screenshot of Vizelia FACILITY Space showing the 3D, color-coded (shaded) view of spaces by type.

Image provided courtesy of Vizelia, Inc.

- ONUMA Planning System™ (www.onuma.com)
- Vizelia suite of FACILITY management products (www.vizelia.com) (see Figure 4-11)

In addition to the general features that any FM system should support, owners should consider the following issues with respect to the use of such tools with building models:

- **Space object support.** Does the tool import “space” objects from BIM authoring tools, either natively or via IFC? If so, what properties does the tool import?
- **Merging capabilities.** Can data be updated or merged from multiple sources? For example, MEP systems from one system and spaces from another system?
- **Updating.** If retrofit or reconfiguration of the facility takes place, can the system easily update the facility model? Can it track changes?
- **Sensor and control monitoring.** Are sensors and control systems part of the FM system? Can they be monitored and managed within the system?

Leveraging a building information model for facility management may require moving to specific BIM facility tools, or to third-party BIM add-on tools,

such as that demonstrated in the Maryland General Hospital case study. This project illustrates how the owner's maintenance team worked with the construction team to handover building model and use it to support commissioning and maintenance by integrating the BIM tool, Tekla Construction Management, with its Computerized Maintenance Management System (CMMS) tool.

One of the challenges with the handover from BIM to the CMMS is the standards and file formats common in BIM tools are not readily accepted by CMMS tools. One standard effort, COBie2 (see Chapter 3), is aimed to support the exchange of maintenance information.

The use of BIM to support facility management is in its infancy and the tools have only recently become available in the marketplace. Owners should work with their facility management organizations to identify whether current facility management tools can support BIM data or whether a transition plan to migrate to BIM-capable facility management tools is required.

4.3.3 Operation Simulation Tools

Operation simulation tools are another emerging category of software tools for owners that use data from a building information model. These include crowd behavior tools, such as Legion Studio, ViCrowd eRena, and Crowd Behavior; hospital procedure simulation, and emergency evacuation or response simulations, such as IES Simulex or building Exodus. Many of them are provided by firms that also offer the services to perform the simulations and add necessary information. In all cases, the tools require additional input of information to perform the simulations; and in some cases, they only extract the geometric properties from the building information model.

More typical examples of operation simulation tools do not involve specialized simulations but the use of real-time visualization or rendering tools that take the building information model as input. For example, one author participated in the development of a 3D/4D model for Disney California Adventure. With specialized tools and services, the same model was used to simulate emergency scenarios for the rollercoaster ride (Schwegler et al. 2000). Likewise, the Letterman Lucas Digital Arts center team used their model to evaluate evacuation and emergency response scenarios (Boryslawski 2006; Sullivan 2007).

4.4 AN OWNER AND FACILITY MANAGER'S BUILDING MODEL

Owners need not only be conversant in the kinds of BIM tools available but also understand the scope and level of detail they desire for a building model

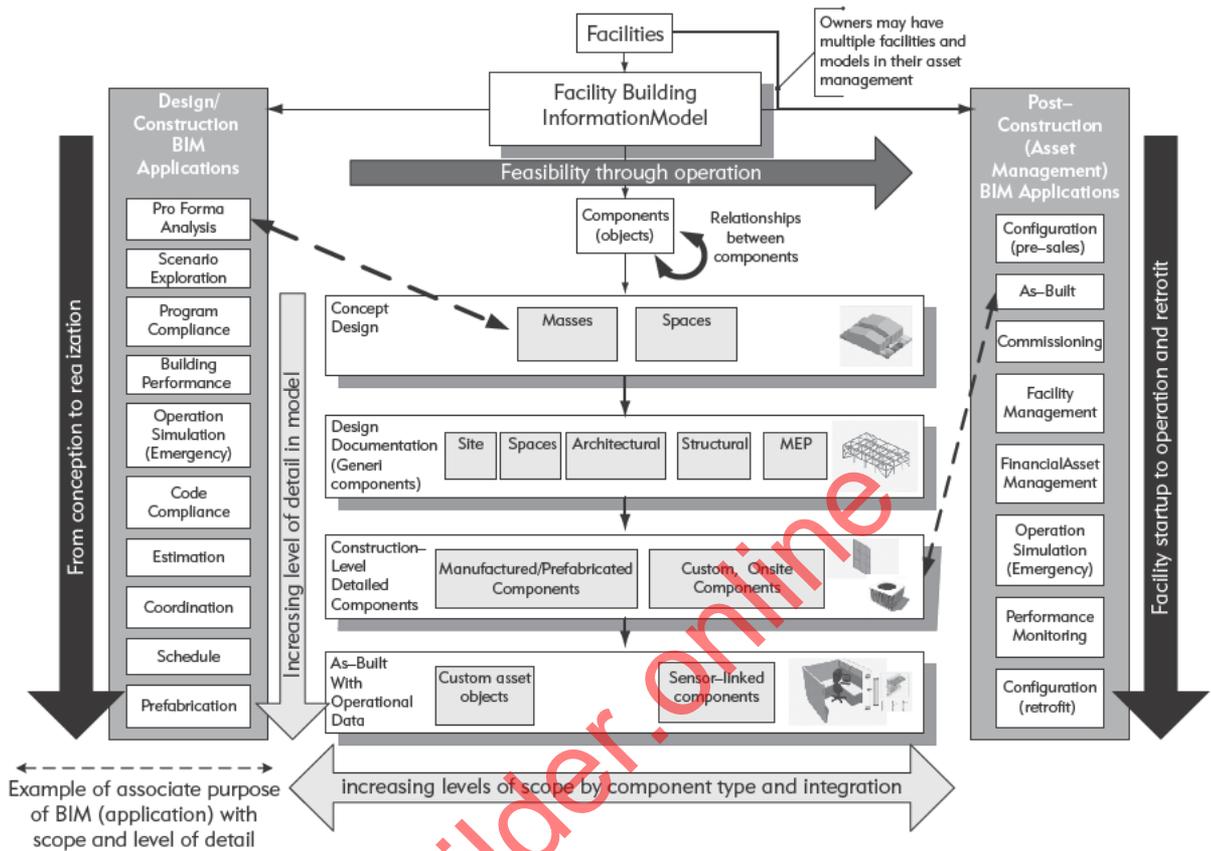


FIGURE 4-12 Conceptual diagram showing the relationship between various BIM applications during the facility delivery process; postconstruction and their relationship to the level of scope and detail in the model.

of their project. In Chapters 5, 6, and 7, we discuss the types of information that designers, engineers, contractors, and fabricators create and add to building information models to support many of the BIM applications. To take advantage of post-construction BIM applications, as discussed in Section 4.2 and listed in Figure 4-12, owners need to work closely with their service providers to ensure that the building model provides adequate scope, level of detail, and information for the purposes intended. Figure 4-12 provides a framework for owners to understand the relationship between the level of detail in a model—masses, spaces, and construction-level detail (see vertical direction)—and the scope of a model, including spatial and domain-specific elements such as architectural and detailed MEP elements.

Often, each service provider defines the scope and level of detail required for their work. The owner can mandate the scope and level of detail required for

Table 4–2 Owner’s Building Information Model

Purpose	Type of Model Information
To support program compliance and facility management. In a typical design process, the spatial information is defined to meet program compliance and support code-checking analysis. These are critical for program compliance and use of the BIM for facility management.	Spaces and functions
To support commissioning activities such as performance specifications	Performance specifications for HVAC and other facility operation equipment
For postconstruction analysis and tracking as well as data for future forecasting	As-built schedule and cost information
To budget and schedule maintenance	Manufactured product information
For replacement costs and time periods and assessment information (See Coast Guard Facility Planning case study)	Financial asset management data
To plan and prepare for evacuation and other emergency crises	Emergency information
To monitor and track progress of design, construction, or maintenance activities	Activity status
To monitor building sensors and real-time control of building systems	Sensor data

post-construction use of the model. For example, at the feasibility stage, masses and spaces are sufficient to support most BIM applications for conceptual design. If the owner requires more integrative BIM applications, then both the level of integration in the model (horizontal) and level of detail (vertical) are increased in the effort to produce the model.

Table 4–2 provides a partial list of some key types of information that the building model needs to support for post-construction use. Some of this information is represented in the IFC schema, as discussed in Chapter 3, and there is a working group within the IAI, the “Facility Management Domain” (www.buildingsmart.com/content/fm_handover_view_aquarium) that addresses facility-specific scenarios, such as move management, work order flows, costs, accounts, and financial elements in facility management. The IAI focuses on the representation of this information within the building model.

Other resources for owners with respect to understanding and defining building information requirements are:

- **OSCRE**[®] (Open Standards Consortium for Real Estate, www.oscre.org). This nonprofit organization is defining information requirements

and standards for transaction-based scenarios, including appraisal, commercial property information exchange, and facilities management work orders.

- **Capital Facilities Information Handover Guide** (NIST and FIATECH 2006). This document defines information handover guidelines for each phase of facility delivery and the building's lifecycle and elaborates many of the information issues discussed in this section.
- **OGC** (Open Geospatial Consortium, www.opengeospatial.org). This nonprofit standards organization is developing standards for geospatial data and has a specific working group looking at the integration of GIS and building model data.

COBie2 (Construction Operations Building Information Exchange, www.wbdg.org/resources/cobie.php). COBie2 simplifies the work required to capture and record project handover data. The COBie2 approach is to enter the data as it is created during design, construction, and commissioning. Designers provide floor, space, and equipment layouts. Contractors provide make, model, and serial numbers of installed equipment. Much of the data provided by contractors comes directly from product manufacturers who can also participate in COBie2 (<http://www.wbdg.org/resources/cobie.php>).

4.5 LEADING THE BIM IMPLEMENTATION ON A PROJECT

Owners control the selection of design service providers, the type of procurement and delivery processes, and the overall specifications and requirements of a facility. Unfortunately, many owners accept the current status quo and may not perceive their ability to change or control how a building is delivered. They may even be unaware of the benefits that can be derived from a BIM process.

Owners cite challenges with changing standard design or construction contracts produced by governing associations such as the American Institute of Architects (AIA) or the Association of General Contractors (AGC). The federal government, for example, faces many barriers to changing contracts since these are governed by agencies and legislatures. These challenges are real and the AIA, AGC, and federal agencies such as the GSA and Army Corps of Engineers are working toward instituting the contracting methods necessary to support more collaborative and integrated methods of procurement

(see Chapters 5 and 6 for a discussion of these efforts). Yet, the case studies and the various projects cited in this book demonstrate a variety of ways in which owners can work within current contractual arrangements and overcome the barriers presented in Section 4.6. Owner leadership and involvement is a prerequisite for optimal use of BIM on a project.

Owners can deliver maximum value to their organization by reviewing and developing BIM guidelines, building internal leadership and knowledge, by selecting service providers with BIM project experience and know-how, and by educating the network of service providers and changing contractual requirements.

4.5.1 Develop Guidelines for BIM on Projects

Many organizations, particularly owners that build and manage multiple facilities, have developed guidelines for BIM. These include government agencies, such as the GSA, Coast Guard, U.S. Army Corps of Engineers, and State of Texas and Wisconsin, and schools, such as Los Angeles Community College District (LACCD), and Indiana University. The real estate owners, Senate Properties, have its BIM Guidelines which contain the following key components:

- Identification of goals for BIM use and its alignment with organizational goals
- Scope and use of BIM across phases of project (for example, a checklist of BIM applications, such as use of BIM for energy analysis or clash detection)
- Scope of standards or formats related to BIM and the exchange of BIM
- Roles of participants in the BIM process and handovers between all participants

Owners should review these guidelines as a starting point and over time develop guidelines that fit their project goals.

4.5.2 Build Internal Leadership and Knowledge

The owner-led BIM efforts in presented in Chapter 9 (Sutter Medical Center; One Island East Office Tower; and Coast Guard Facility Planning) share two key processes: (1) the owner first developed internal knowledge about BIM technologies; and (2) the owner dedicated key personnel to lead the effort. For example, in the Sutter Medical Center project, the owner examined internal work processes intensively and identified the tools and lean methods that

could deliver the facilities more efficiently. On these projects, the owners did not develop the full knowledge of how to implement various BIM applications but created a project environment where service providers could constructively apply appropriate BIM applications.

The One Island East Office Tower case study shows a slightly different approach to building that knowledge. The owner, Swire Properties Inc., had done extensive research to improve the company's ability to better deliver and manage their facilities and properties. They identified barriers related to the management of 2D information and the wide variety of project information. When they were presented with the concepts of building information modeling, they had the internal knowledge to know where to apply and leverage available BIM technologies.

The U.S. Coast Guard is building its internal knowledge and defining a roadmap for implementing BIM, as discussed in the Coast Guard Facility Planning case study (Brucker et al. 2006). This roadmap is a phased approach to implementing BIM across their organization and various facility projects. The knowledge necessary to build such a roadmap was the result of pilot projects and a significant investigation and research effort led by various groups within the U.S. Coast Guard. The roadmap includes both milestones related to specific BIM technology applications for managing project information and facility assets as well as milestones for procuring and delivering facilities using various BIM applications.

All of these cases demonstrate owners that developed knowledge through an exploration of their own internal business models and work processes related to delivering and operating facilities. They understood the inefficiencies inherent in their current work processes and how they impacted the bottom line. In so doing, key members of the staff were equipped with the knowledge and skills to lead the BIM effort.

4.5.3 Service Provider Selection

Unlike the case in global manufacturing industries, such as that of automobiles or semiconductors, no single owner organization dominates the building market. Even the largest owner organizations, which are typically government agencies, represent only a small fraction of the overall domestic and global facility markets. Consequently, efforts to standardize processes, technologies, and industry standards are far more challenging within the AEC industry than in industries with clear market leaders. With no market leaders, owners often look at what their competition is doing or to industry organizations as guides for best practice or latest technology trends. In addition, many owners build or

initiate only one project and lack expertise to take a leadership position. What all owners share, though, is the control over how they select service providers and the format of project deliverables.

Owners can use a number of methods to ensure that the service providers working on their project are conversant in BIM and its related processes:

Modifying job skill requirements to include BIM-related skills and expertise

For internal hires, owners can require prospective employees to have specific skills, such as 3D and knowledge of BIM or component-based design. Many organizations are now hiring employees with BIM-specific job titles such as *BIM Specialist*, *BIM Champion*, *BIM Administrator*, *4D Specialist*, and *Manager, Virtual Design and Construction*. Owners may hire employees with these titles or find service providers that bear similar ones. Some examples of job skill requirements are detailed in the box titled “Examples of Job Skill Requirements” (J.E. Dunn 2007).

Including BIM-specific prequalification criteria

Many Requests for Proposals (RFPs) by owners include a set of prequalification criteria for prospective bidders. For public works projects, these are typically standard forms that all potential bidders must fill out. Commercial owners can formulate their own prequalification criteria. An excellent example is the qualification requirements formulated by hospital owner Sutter Health that are described in the Medical Building case study in Chapter 9. These include explicit requirements for experience and the ability to use 3D modeling technologies.

Interviewing prospective service providers

Owners should take the time to meet designers face-to-face in the prequalification process, since any potential service provider can fill out a qualification form and note experience with specific tools without having project experience. One owner even prefers meeting at the designer’s office to see the work environment and the types of tools and processes available in the workplace. The interview might include the following types of questions:

- What BIM technologies does your organization use and how did you use them on previous projects? (Perhaps use a modified list of BIM application areas from Table 4–1 as a guide.)
- What organizations collaborated with you in the creation, modification, and updating of the building model? (If the question is asked to an architect, then find out if the structural engineer, contractor, or

Examples of Job Skill Requirements

- Minimum three to four years' experience in the design and/or construction of commercial buildings structures
- B.S. Degree (or equivalent) in construction management, engineering, or architecture
- Demonstrated knowledge of building information modeling
- Demonstrated proficiency in one of the major BIM applications and familiarity with review tools
- Working knowledge and proficiency with any of the following: Revit, ArchiCAD, Navisworks, SketchUp, Autodesk® Architectural Desktop, and Building Systems (or other specific BIM applications that your organization uses)
- Solid understanding of the design, documentation, and construction processes and the ability to communicate with field personnel

prefabricator contributed to the model and how the different organizations worked together.)

- What were the lessons learned and metrics measured on these projects with respect to the use of the model and BIM tools? And how were these incorporated into your organization? (This helps to identify evidence of learning and change within an organization.)
- How many people are familiar with BIM tools in your organization and how do you educate and train your staff?
- Does your organization have specific job titles and functions related to BIM (such as those listed previously)? (This indicates a clear commitment and recognition of the use of BIM in their organization.)
- How will you turn over the BIM model(s) used on this project and how can I transfer the information needed for my facility management system?

4.5.4 Build and Educate a Qualified Network of BIM Service Providers

One of the challenges for owners is finding service providers proficient with BIM technologies within their existing network. This has led several owners to lead proactive efforts to educate potential service providers, internal and

external, through workshops, conferences, seminars, and guides. Here are three examples:

Formal education. The United States General Services Administration has established a National 3D/4D BIM Program (General Services Administration 2006). Part of this effort includes educating the public and potential service providers and changing how they procure work (see Section 4.5.5). The educational efforts include working with BIM vendors, professional associations such as the AIA and AGC, as well as standards organizations and universities, by sponsoring seminars and workshops. Each of the ten GSA regions has a designated BIM “champion” to push adoption and application to projects in their respective regions. For example, the authors have each been invited to present BIM concepts to various owners’ groups, both in the United States and other parts of the world. Unlike some commercial organizations, the GSA does not view its BIM expertise and knowledge as proprietary and recognizes that for the GSA to ultimately benefit from the potential of BIM, all project participants need to be conversant with BIM technologies and processes.

Informal education. Sutter Health’s educational efforts are largely centered around implementing lean processes and BIM technologies on their projects. Sutter invited service providers to attend informal workshops with presentations on lean concepts, 3D, and 4D. Sutter also supports project teams using BIM technologies to conduct similar workshops open to industry professionals. These informal workshops provide ways for professionals to share experiences and learn from others and ultimately to widen the number of service providers available to bid on future Sutter projects.

Training support. A critical part of education, beyond teaching BIM concepts and applications, is related to technical training for specific BIM tools. This often requires both technical education of BIM concepts and features for transitioning from 2D- to 3D-component parametric modeling as well as software training to learn the specific features of the BIM tools. For many service providers, the transition is costly, and it is difficult to justify initial training costs. Swire Properties (see One Island East Office Tower case study in Chapter 9) recognized this as a potential barrier and paid for the training of the design team to use specific BIM tools on their project.

4.5.5 Change Deliverable Requirements: Modify Contracts and Contract Language

Owners can control which BIM applications are implemented on their projects through the type of project delivery process they select and with BIM-specific

contractual or RFP requirements. Changing the delivery process is often more difficult than changing the requirements. Many owners first start with changes in the RFP and contracts in three areas:

1. Scope and detail of the model information

This includes defining the format of project documentation and changing from 2D paper to a 3D digital model. Owners may choose to forego specific requirements pertaining to the 3D format and the types of information service providers include in the model (see Figure 4–12 and Section 4.4); or owners can provide detailed language for those requirements (see the Sutter Medical Center case study in Chapter 9). As owners gain experience, the nature of these requirements will better reflect the types of BIM applications an owner desires and the information that the owner team demands throughout the delivery process and subsequent operation of the facility. Table 4–3 provides a reference for the types of information an owner should consider relative to desired BIM applications.

2. Uses of model information

This includes specifying services more readily performed with BIM tools, such as 3D coordination, real-time review of design, frequent value engineering using cost estimating software, or energy analysis. All of these services could be performed with traditional 2D and 3D technologies; but providers using BIM tools would most likely be more competitive and capable of providing such services. For example, 3D coordination is greatly facilitated through BIM tools. Tables 4–1, 4–2, and 4–3 provide a summary of the BIM applications owners can use as a basis to describe the services relevant to their specific projects.

3. Organization of model information.

This includes project work breakdown structure and is discussed in Section 4.3.1. Many owners overlook this type of requirement. Today, CAD layer standards or Primavera activity fields are templates for how designers organize the project documentation and the building information. Similarly, owners or the project team need to establish an initial information organization structure. This may be based on the geometry of the project site (Northeast section) or the building structure (East wing, Building X). The One Island East case study discusses the project work breakdown structure that the teams employed to facilitate the exchange of building BIM and project documentation. Efforts are underway to establish building model standards, such as the National Building Information Model Standard. This standard should provide much-needed definition

and a useful resource for owners to define the project work breakdown structure. The U.S. Coast Guard, for example, references these within their milestones.

These requirements, however, are often difficult to meet without some modifications to the fee structure and relationships between project participants or without the use of incentive plans that define the workflow and digital hand-offs between disciplines. Often, these are more difficult to define in a workflow centered on a digital model, as opposed to files and documents. Additionally, approval agencies still require 2D project documentation as do a majority of professional contracts. Consequently, many owners maintain the traditional document and file-based deliverables (see Figure 4–13); and they insert digital 3D workflows and deliverables into the same process. That is, each discipline works independently on their scope and BIM applications and hands-off the 3D digital model at specified times. Clearly, this is not a desirable approach to using BIM to its maximum advantage.

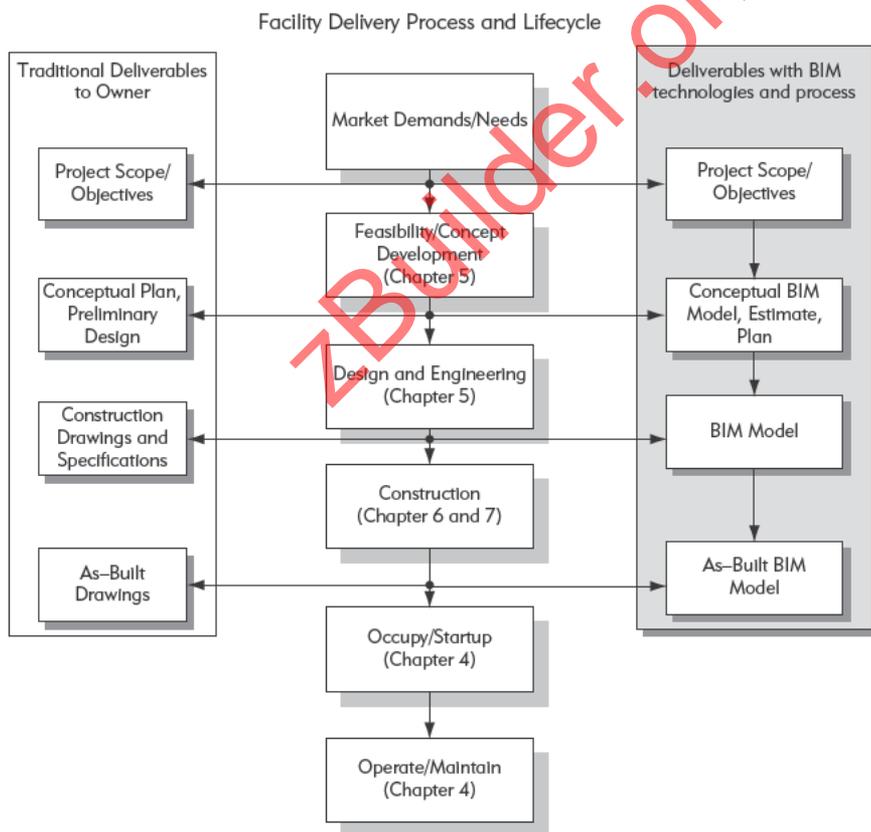


FIGURE 4–13

Typical contract deliverables resulting from the traditional design-bid-build process as compared to the types of deliverables that result from a collaborative BIM-based process such as IPD.

Owners will need to change contracts and language to promote the use of BIM.

Modified design-build delivery. The GM Production Plant project (see Section 9.1 of the first edition of the *BIM Handbook*) demonstrates a collaborative process achieved through modifications to the design-build delivery process. GM hired the design-build team and then participated in the selection of subcontractors and additional design consultants. The goal was to form the team as early as possible and engage them from the outset.

Performance-based contracts. Performance-based contracts or performance-based acquisition (PBA) focus on results, are typically fixed-fee, and allow service providers to deliver a facility or their services using their own best practices (Department of Defense 2000). This emphasizes the outcome, as defined by the owner, rather than intermediate milestones or deliverables. Many government agencies are moving to this approach, targeting 40 to 50 percent of new work using this approach (General Services Administration 2007). This type of contract typically requires that the owner spend more time early in the project to define the facility requirements and structure the contracts to accommodate such an approach. This approach may seem a contradiction to the previous recommendations; but service providers utilizing BIM will most likely be more competitive and requirements can be BIM-based.

Shared incentive plans. Performance-based contracts are often implemented with shared incentive plans. When all members collaborate on most phases of building, there is no clear partitioning of organization contributions. This is the intent of IPD arrangements, introduced in Section 4.1. The Sutter Medical Center case study in Chapter 9 provides an example of a shared incentive plan designed to distribute cost savings to the project team. It provides financial incentives based on the overall project performance and not solely on individual organizational performance. These plans are often difficult to define and implement, as the case study demonstrates. Nonetheless, shared incentive plans reward teams for collaborative performance rather than local optimization of discipline-specific performance.

These different procurement methods do not address situations where owners perform some or all of the design, engineering, or construction services. Outsourcing is a common trend for many owners (Geertsema et al. 2003). There are some owner organizations that have construction management and construction superintendents on staff. In such cases, as discussed in Section 4.7, the owner must first assess their internal capabilities and work processes. The “wall” of deliverables can exist internally, and defining model handover requirements between internal groups is just as critical. The owner must ensure that

all participants, internal or external, can contribute to the creation, modification, and review of the building model. This may involve the owner requiring the use of specific software or data formats to exchange data.

Outsourcing, however, does have an impact on the overall BIM effort, and owners who choose to hire a third party to produce the building information model independent of the project's internal and external team of service providers should carefully consider full outsourcing of the model. Typically, the outsourcing effort leads to a building information model that is underutilized, outdated, and of poor quality. This occurs for several reasons. First, the internal or external team has to reach a specified point in the project to hand over the traditional documentation. Second, the outsource team must spend significant time, often with little contact since the team is now busy working toward the next deliverable, to understand and model the project. Finally, the outsource team does not typically have highly skilled or experienced staff with building knowledge. Thus, outsourcing should be done with considerable attention and management oversight or be used as an effort to support the BIM effort, not replace it. The One Island East Office Tower case study is an excellent example of working with external resources to develop the building model while integrating its resources into the project team both physically and virtually. Another example is the Letterman Digital Arts project in San Francisco, where the owner hired an outside firm to build and maintain the building model (Sullivan 2007). In both cases, the critical success factor was attributed to bringing the resources onsite and mandating participation by all project participants.

4.6 BARRIERS TO IMPLEMENTING BIM: RISKS AND COMMON MYTHS

There are risks associated with any changes to work processes. Realistic and perceived barriers and changes related to implementing BIM applications on projects are no exception. These barriers fall into two categories: process barriers to the business, including legal and organizational issues that prevent BIM implementation; and technology barriers related to readiness and implementation. These are summarized below.

4.6.1 Process Barriers

The market is not ready—it's still in the innovator phase. Many owners believe that if they change the contracts to require new types of deliverables, specifically 3D or building information models, they will not receive competitive bids, limiting their potential pool of bidders and ultimately increasing the price

of the project. Recent surveys, however, do indicate that a majority of service providers are using BIM technologies (to various extents) on their projects. The degree of adoption varies from just using BIM to generate drawings to full participation in IPD teams.

- **Adoption among architects, engineers, and contractors has moved well beyond the “early adopters” stage.** By 2009, more than 50 percent of each of these groups reported using BIM at moderate levels or higher (Young et al. 2009). In 2007, only 34 percent of architects claimed they used 3D/BIM tools for “intelligent modeling” (i.e., not simply for the generation of 2D drawings and visualizations) (Gonchar 2007). In 2000, the use of intelligent modeling was rare.
- Adoption of BIM by regulatory agencies for review of proposed new buildings or modifications to existing buildings is negligible in the United States, but there is some progress in other countries e.g., CORENET, 2010.

The case studies in this book, and many of its bibliographical references, indicate a transition from innovator to early adopter phase for design-related BIM applications. As the use of BIM increases, owners will find increasing numbers of service providers capable of using BIM.

The Project Is Already Financed and Design Is Complete—It’s Not Worth It to Implement BIM

As a project nears construction, it’s true that owners and the project team will miss valuable opportunities available through the use of BIM applications, such as conceptual estimating and program compliance. There is still ample time and opportunity, however, to implement BIM in the latter stages of design and through the early phases of construction. For example, the BIM implementation in the One Island East Office Tower case study began after construction documents were started. The BIM implementation on the Letterman Digital Arts Center, driven by the owner, began postdesign and resulted in significant identification of design discrepancies and estimated cost savings of \$10 million (Boryslawski 2006). The team, however, recognized that had the effort started earlier even more cost savings and benefits would have been realized.

Training Costs and the Learning Curve Are Too High

Implementing new technologies such as BIM technologies is costly in terms of training and changing work processes and workflows. The dollar investment in software and hardware is typically exceeded by the training costs and initial

productivity losses. This can be seen clearly in the adoption cash flow example in Chapter 7. Often, most service providers are not willing to make such an investment unless they perceive the long-term benefit to their own organization and/or if the owner subsidizes the training costs. In the One Island East Office Tower case study, the owner understood that the potential gains in productivity, quality, and asset management outweighed the initial costs and paid for the training.

Everyone Must Be on Board to Make the BIM Effort Worthwhile

It is often difficult to ensure that all project participants have the know-how and willingness to participate in the creation or use of the building information model. Many of the case studies in Chapter 9 demonstrate the benefits of BIM implementation without full participation but also highlight challenges with recreating information from organizations not participating in the modeling effort.

Too Many Legal Barriers Exist and They Are Too Costly to Overcome

Contractual and legal changes are required on several fronts to facilitate the use of BIM and more collaborative project teams. Even the digital exchange of project information is sometimes difficult today, and teams are often forced to exchange only paper drawings and rely on old-fashioned contracts. Public institutions face even greater challenges, since they are often governed by laws that take considerable time to change. Nonetheless, several government agencies and private companies have overcome these barriers and are working toward contract language that not only changes the nature of how information is exchanged within the project team but the liability and risks associated with a more collaborative effort. The Sutter Medical Center is an example of this.

The primary challenge is the assignment of responsibility and risk. BIM implementation centralizes information that is “broadly accessible,” depends on constant updating, and subjects designers to increased potential liability (Ashcraft 2006). The legal profession recognizes these barriers and the necessary risk-allocation changes that need to take place. This is a real barrier, one that will continue to persist and will depend on professional organizations such as the AIA and AGC to revise standard contracts and/or owners to revise their own contract terms.

Issues of Model Ownership and Management Will Be Too Demanding on Owner Resources

BIM potentially requires insight across multiple organizations and aspects of the project. Typically, a construction manager (CM) provides the oversight by managing communication and reviewing project documentation. The CM also

oversees that the process is aligned with specific deliverables and milestones. With BIM, issue discovery and problem identification occur early and more frequently, enabling teams to resolve issues early; but this often requires owner input, which should be seen as a benefit and not a drawback. The current slack in the delivery process is significantly reduced, demanding more direct owner involvement. The process is more fluid and interactive. Owner-requested changes will become less transparent and the impacts of these changes will demand ongoing participation. Managing this process and the related management of the model will become critical to the project. Owners need to establish clear roles and responsibilities and methods to communicate with the project team and ensure that an owner representative is available as needed.

4.6.2 Technology Risks and Barriers Technology Is Ready for Single-Discipline Design but Not Integrated Design

It is true that two to five years ago the creation of an integrated model required extensive effort on the part of a project team and dedicated technical expertise to support that integration. Today, many of the BIM design tools reviewed in Chapter 2 have matured and provide integration capabilities between several disciplines at the generic object level (see Figure 4–13). As the scope of the model and number and types of building components increase, however, performance issues also increase. Thus, most project teams choose to use model review tools to support integration tasks, such as coordination, schedule simulation, and operation simulation. The Castro Valley Medical Center and the Crusell Bridge projects, for example, used the Navisworks model review tool to perform clash detection and design coordination. Currently, BIM design environments are typically good for one- or two-discipline integration. The integration of construction-level detail is more difficult, and model review tools are the best solution to achieve this.

A greater barrier is related to work process and model management. Integrating multiple disciplines requires multiuser access to the building information model. This does require technical expertise, establishment of protocols to manage updates and edits of the model, and establishing a network and server to store and access the model. It also provides an excellent context for new users to learn from more experienced ones.

Owners should perform audits with their project teams to determine the type of integration and analysis capabilities that are desired and currently available and prioritize accordingly. Full integration is possible but does require expertise, planning, and proper selection of BIM tools.

Standards Are Not Yet Defined or Widely Adopted—So We Should Wait

Chapter 3 discusses the various standards efforts, such as IFCs and the National BIM Standards, which will greatly enhance interoperability and widespread BIM implementation. The Crusell Bridge and Helsinki Music Hall case studies (Chapter 9), both in Finland, illustrate the effective use of IFC-based model exchange. Although software companies have improved their IFC import and export functions, designers have not yet learned to make optimal use of the exchange standards, and many organizations use proprietary formats for model exchange. For owners, this may pose a risk to the short- and long term-investments in any building information modeling effort. There are owner-specific standardization efforts related to real estate transactions and facility management, as discussed previously; however, the case studies in this book demonstrate that a variety of successful BIM implementations have been achieved without reliance on these standards; and it is not a barrier to implementation.

4.7 GUIDELINES AND ISSUES FOR OWNERS TO CONSIDER WHEN ADOPTING BIM

Adopting BIM alone will not necessarily lead to project success. BIM is a set of technologies and evolving work processes that must be supported by the team, the management, and a cooperative owner. BIM will not replace excellent management, a good project team, or a respectful work culture. Here are some key factors an owner should consider when adopting BIM.

Perform a pilot project with a short time frame, small qualified team, and a clear goal

The initial effort should use either internal resources or trusted service providers that your organization has worked with. The more knowledge an owner builds with respect to the implementation and application of BIM, the more likely future efforts will succeed, as the owner develops core competencies to identify and select qualified service providers and forge cooperative teams.

Do a prototype dry run

When doing a pilot project, it's always best to do a dry run and make sure the tools and processes are in place to succeed. This may be as simple as giving the designer a small design task that showcases the desired BIM applications. For example, the owner can ask the design team to design a conference room for twenty people, with specific targets for budget and

energy consumption. The deliverable should include a building information model (or models to reflect two or three options) and the related energy and cost analyses. This is an example of a design task that is achievable in one or two days. The architect can build the model and work with an MEP engineer and estimator to produce a set of prototype results. This requires that the project participants work out the kinks in the process, so to speak, and also allows the owner to provide guidance regarding the types of information and formats of presentation that provide clear, valuable, and rapid feedback.

Focus on clear business goals

While this chapter cites many different benefits, no single project has yet achieved all of these benefits. In many cases, the owner started with a specific problem or goal and succeeded. The GSA's pilot project efforts (Dakan 2006), for example, each involved one type of BIM application for nine different projects. The application areas included energy analysis, space planning, laser scanning to collect accurate as-built data, and 4D simulation. The success in meeting focused and manageable goals led to expanded use of multiple BIM applications on projects such as the evolving use of BIM on the Crusell Bridge case study in Chapter 9.

Establish metrics to assess progress

Metrics are critical to assessing the implementation of new processes and technologies. Many of the case studies include project metrics, such as reduced change orders or rework, variance from baseline schedule or baseline cost, and reduction in typical square footage cost. There are several excellent sources for metrics or goals relevant to specific owner organizations or projects, including:

- **Construction Users Roundtable (CURT)**. This owner-led group holds workshops and conferences and issues several publications on their Web site (www.curt.org) for identifying key project and performance metrics.
- **CIFE Working Paper on Virtual Design and Construction** (Kunz and Fischer, 2007). This paper documents specific types of metrics and goals along with case study examples.

Also, see Section 5.5.1 for the development of assessment metrics related to design.

Participate in the BIM effort

An owner's participation is a key factor of project success, because the owner is in the best position to lead a project team to collaborate in ways that exploit BIM to its fullest benefit. All of the case studies in which

owners took leadership roles demonstrate the value of the owner's participation in proactively leading the BIM implementation. They also highlight the benefits of ongoing involvement in that process. BIM applications, such as those for BIM design review, enable owners to better participate and more easily provide the necessary feedback. The participation and leadership of owners is critical to the success of the collaborative project teams that exploit BIM.

Chapter 4 Discussion Questions

1. List three types of procurement methods and how these methods do or do not support the use of BIM technologies and processes.
2. Imagine you are an owner embarking on a new project and have attended several workshops discussing the benefits of BIM. What issues would you consider when deciding whether you should support and promote the use of BIM on your project?
3. If the owner did decide to adopt BIM, what types of decisions would be needed to ensure the project team's success in using BIM at each stage of the building lifecycle?
4. With respect to the application and benefits of BIM technologies and processes, what are the key differences between an owner who builds to sell a facility versus an owner who builds to operate?
5. Imagine you are an owner developing a contract to procure a project using a collaborative approach through the use of BIM. What are some of the key provisions that the contract should include to promote team collaboration, the use of BIM, and project success?
6. List and discuss three risks associated with using BIM and how they can be mitigated.
7. List two or three processes or project factors that influence the success of BIM implementation.
8. Imagine you are an owner building your first project and plan to own and occupy the facility for the next 15 to 20

years. You do not plan to build another facility and will outsource its design and construction. Should you consider BIM? If so, list two or three reasons why BIM would benefit your organization, and describe what steps you might take to achieve the benefits you cite. If you believe that BIM would not benefit your project, explain why.

9. List three market trends that are influencing the adoption and use of BIM and how BIM enables owners to respond to those market trends.

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