BIM and Construction Management

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This chapter introduces building information modeling (BIM). It discusses why BIM is becoming the industry standard and how it is transforming the global construction community at large. This chapter defines a new way of thinking about BIM as a process, not just as software, and specifically explores the following topics:

In this chapter

The value and potential of BIM technology
Existing delivery methods
A new concept of delivery
A new concept of process
The ten steps for successful implementation

The Value and Potential of BIM Technology

BIM is a revolutionary technology and process that has transformed the way buildings are designed, analyzed, constructed, and managed. Currently, an overwhelming amount of information is available about BIM, such as theories on where BIM can go, the vast array of tools available, and how BIM seems to be the answer to all the problems facing a construction manager (CM). Although some of this information is useful, often it inundates potential users because the information all seems to meld together. BIM has become a proven technology. What it can do and the concepts associated with BIM taken out of context, however, can become misleading and frustrate users and owners alike to the point of not wanting to use this technology again on future projects. This not only hurts the future growth of BIM technology, but it inhibits users from getting involved and sharing their experiences with others in the BIM community to further refine lessons learned and best practices. Figure 1.1 shows an example of a building constructed using BIM technology.

Courtesy of McCownGordon Construction, LLC.

Figure 1.1 Sunset Drive office building, a LEED Gold building constructed using BIM technology

BIM works. While there currently are a number of inefficiencies that will continue to be refined, BIM as a technology is no longer in its infancy and has started to produce results for the AEC/O industry all over the world. The new frontier for BIM and for its users is to define a new process that better enables this new technology. This book identifies a new process and a way of thinking about BIM that is different than previous processes based off older technology.

BIM: A Primer

So, what is BIM? As Charles Eastman puts it in *Building Product Models: Computer Environments Supporting Design and Construction* (CRC Press, 1999), "BIM is a digital representation of the building process to facilitate exchange and interoperability of information in digital format." For a contractor, BIM is the virtual construction of a facility or structure that contains intelligent objects in a single source file that, when shared among project team members, intends to increase the amount of communication and collaboration. The words *communication* and *collaboration* have become common in discussions about BIM today, not only among architects, engineers, and contractors but also with owners, facility managers, and sustainable design professionals. In fact, according to *Interoperability in the Construction Industry* (McGraw Hill Construction, 2007), construction productivity has decreased significantly over the last forty years. This is in large part because of a lack of communication and collaboration through information (Figure 1.2).

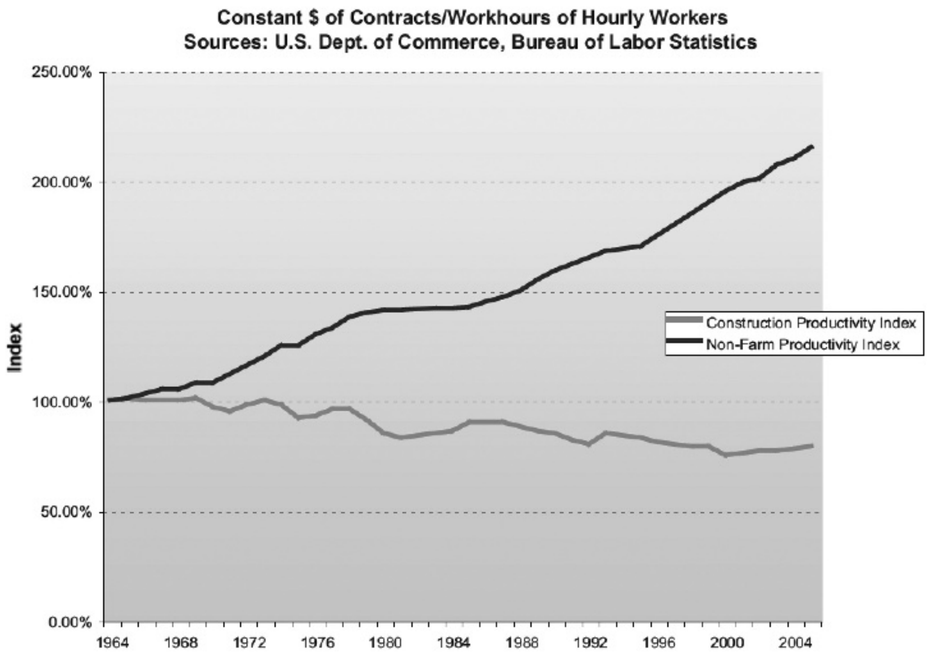


Figure 1.2 Construction productivity index compared to nonfarm industries

Informed contractors and sophisticated owners have begun to look at the current processes and demand higher interoperability among teams and among software packages, better tools, fewer change orders, and fewer questions in the field.

The question then becomes, how? How can building professionals begin to deliver better projects to their owners even as buildings become more and more complex and dependent on new technologies in an ever-changing and moving world? One of the loudest answers has been BIM.

BIM is not just software. BIM is a process *and* software. Many believe that once they have purchased a license for a particular piece of BIM software, they can sit someone in front of the computer and they are now "doing BIM." What many don't realize, though, is that building information modeling means not only using three-dimensional modeling software but also implementing a new way of thinking. It is in essence a new way of *not* doing the same old thing. In my experience, as a company integrates this technology, it begins to see other processes start to change. Where a certain process might have made perfect sense for a CAD-type technology, now that doesn't seem to be as efficient. As the technology changes, so do the practices and functions of the people using the technology. In other words, don't expect to begin adapting to this new technology and have everything function as it has in the past. Chances are that very few of your practices will remain the same, because when the information is much richer and more robust, the management of this information must change in order to fully utilize its potential. Although it is clear that many BIM technologies continue to grow and develop, it is even more apparent that the "old way of doing things" has a limited future.

So, what are the advantages of BIM? Let's first look at the owner's perspective. According to *Interoperability in the Construction Industry*, 49 percent of owners are now demanding BIM be used on their projects (Figure 1.3). Right behind the owners' demand for BIM, 47 percent of construction industry professionals are choosing to use BIM for its "ability to improve communication with clients/others in the design and construction process." Clearly, BIM is being perceived by owners as a tool that can better coordinate and manage building information. Additionally, construction industry professionals are choosing to use BIM to improve the design and construction process. Although the technology is key, it is perhaps even more critical to define processes that utilize this technology and how to work better with all members involved.

BIM and the Team

What does BIM mean to other team members? Architects use it to more efficiently model their designs (it's not drafting anymore), to generate the documents that are required of them, and to perform a host of other tasks. Designers using BIM can quickly generate rendered perspective views and animations to better communicate the project to the owner or local municipalities. Engineers can model mechanical and electrical designs to evaluate how a system will perform. Sustainability consultants, architects, and engineers can measure day lighting, recycled and reused material content, and solar orientation. In essence, any physically modeled object can be created, infused with data, analyzed, scheduled, and tested.

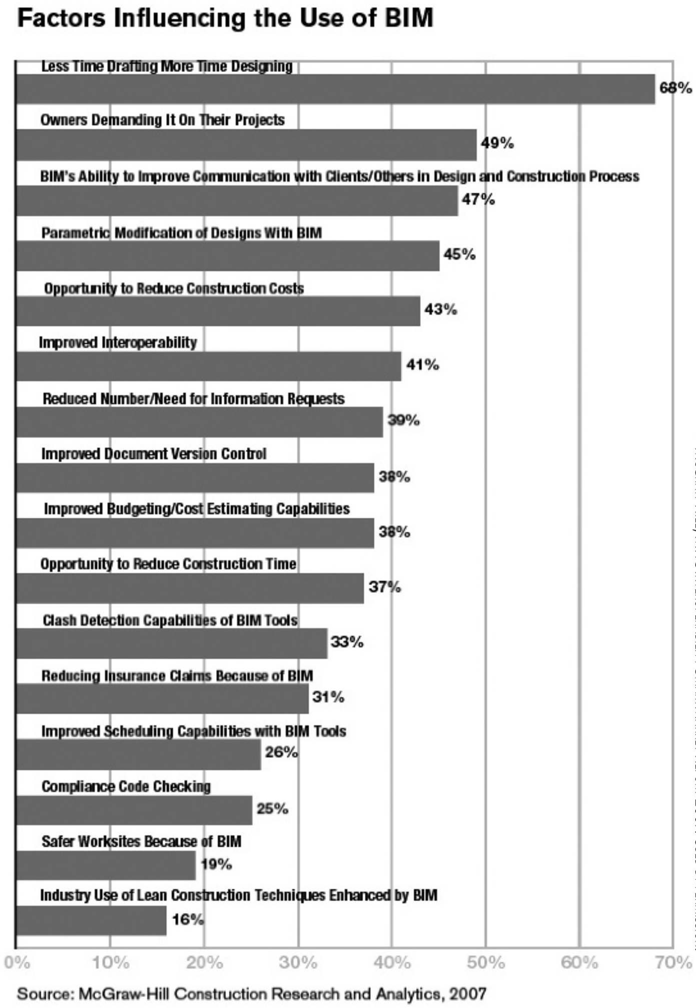


Figure 1.3 Industry factors influencing the use of BIM

Existing Delivery Methods

So, why does BIM matter to contractors? To really understand the answer to this question, you need to first look at current processes to see how information is shared, what types of technologies are being used, and what types of project delivery methods are being used. Therefore, in the following sections, I'll introduce you to four current project delivery methods: design-bid-build, design-build, CM-at-risk, and integrated project delivery. I'll talk about each method in the context of five categories, specifically in regards to information and workflow:

- Preconstruction
- Communication and collaboration methods

- Types of documents
- Clarification of information
- Project closeout

The four methodologies discussed are practiced using CAD technology. Although the type of project delivery varies for the purposes of this discussion, I will cover the most popular methods and how information flows within each of them. As there are other types of delivery methods, these commonly practiced methods will begin to paint a picture of how information is currently shared among teams and the last method will explore a potential future means of project delivery.

Design-Bid-Build

Design-bid-build is one of the most traditional types of delivery methods practiced today. The basic concept behind design-bid-build is a linear process. The owner contracts with the architect to develop a program and then further develops the design using mechanical, electrical, and plumbing engineers. After the design has been solidified, the project moves into construction documentation, with the understanding that the design team will produce completed construction documents for the project to be issued to a number of general contractors to bid on. The role of the general contractor on this type of delivery is to take the documents and specifications and work with subcontractors to define their relevant scope of work and deliver a bid for the project. Using these subcontractors' estimates, the general contractor then compiles a completed bid. This bid is then delivered to the owner, and at this point all other bids on the project are opened either privately or publicly depending on the project type. The owner then awards the general contractor the project's contract based upon price to complete the project.

The design-bid-build delivery method has these problems:

- If a contractor has been consulted to complete an estimate on the project during construction documentation, the project may go over its scheduled delivery date because of additional drawing time due to value engineering.
- It assumes that cheaper is better. Although that assumption might be correct in regard to cost, it is not necessarily accurate in regard to project quality or the ability of the contractor to adequately perform the work or collaborate with the team.
- In a design-bid-build delivery it is the assumption that by promoting competition among general contractors the best possible price will be issued.
- The owner is at risk to the contractor for design errors.

General contractors' bids on this type of project may vary wildly because of both internal and perceived external issues on the project. First, if a general contractor is backlogged and has too much work on their plate, they might bid the project higher. This contractor wants to complete the work they already have and justify the additional cost through staff adjustment, overtime, and other overhead costs to complete the work. Second, the general contractor will gauge the aptitude of the design team based on the documents. Because this is often the only means of collaboration with the design team that the contractor will have during a bid process, aside from a pre-bid meeting, they will raise or lower their costs depending on the detail and accuracy of the documents. Lastly, the contractor is at risk of not being selected. Typically general contractors spend a considerable amount of time and money on producing a bid, and there is a high risk for not being rewarded for that investment. Additionally, even if they are the low bidder on the project, the owner reserves the right to not accept any of the bids regardless of the cost. This drives some contractors to work with owners under other delivery methods that validate their investment of resources to receive a project.

Preconstruction

In a design-bid-build contract (Figure 1.4), typically no information is shared in schematic design (SD) or design development (DD) between the architect and contractor. Although a contractor might be involved with a design-bid-build project as an owner's representative or in a design-assist capacity, often that contractor is involved purely for estimate checking and cannot bid on the project, because they might have additional information that would be an advantage over the other bidders and because their contract is for a predetermined fee separate from the construction contract. Since little to no contractor involvement during preconstruction severely limits the design team's ability to make informed design decisions, the design team is forced to issue "value engineering" options or "deduct" options to reduce the bid amounts for the project.

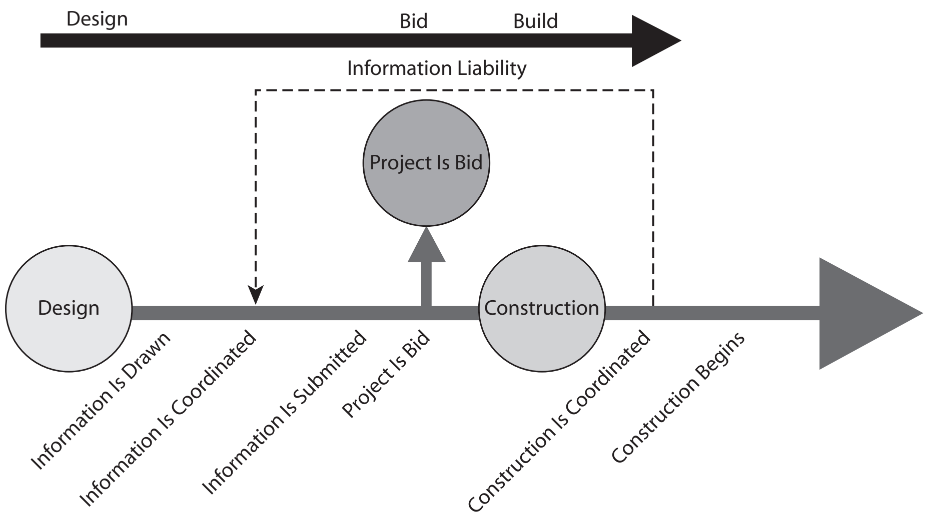


Figure 1.4 Design-bid-build information flow

Design-bid-build is not all bad, in that it allows the architects and engineers some time to collaborate effectively and produce relatively integrated documents. Design-bid-build also gives the owner control of the project, but requires a high level of owner expertise and resources. In regard to BIM it is mostly ineffective. The design-bid-build delivery method limits the ability for BIM to be used to its full potential as a coordination tool by the contractor. In regard to scheduling, clash detection, constructability, and estimating, the model is somewhat of an afterthought, because the drawings take precedence and because the architects and engineers are under no obligation to even share the model—if it exists—with the contractor. In reality, BIM is not useful in a design-bid-build with the exception of trying to use it to quickly extract quantities for estimating purposes from a model of unknown quality. The attitude for model sharing is sometimes tentative if language has not been worked into the contractual agreements, or other waivers have not been signed because the architects and engineers don't want to legally expose themselves to misinterpretation of information any more than they already do.

Communication and Collaboration Methods

Depending on the type and schedule of the project, information is often not shared with the construction team until the 100 percent construction documentation (CD) phase. Drawings are distributed from the architect or local print shop, at which point the contractor then takes either the sheet drawings or the digital PDF and CAD files and performs a *takeoff*. The takeoff process, in the case of the sheet drawings, is done using document tracing software, manual takeoff, or on a digitizer (Figure 1.5).

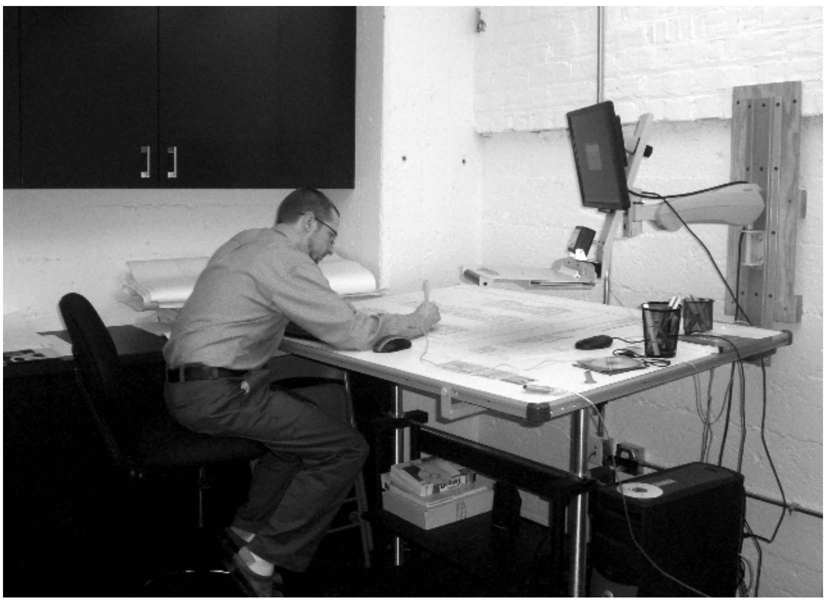


Figure 1.5 Using a digitizer to complete an estimate takeoff

A digitizer helps an estimator trace documents and quantify items such as walls, floors, and ceilings and counts the number of doors, fixtures, and equipment, while also flipping through corresponding drawings to see whether the drawings paint a clear picture of the design intent as communicated by the architects and engineers. This process is disconnected in that it relies entirely on the ability of the estimator to correctly interpret drawings that are assumed to be accurate. The problem with the digitizer method of takeoff is that the level of interpretation left to the person doing it is great; often, a significant amount of misinterpreted data is input into the estimate. The other resource that is being consumed in great quantity here is time. Especially on larger, more sophisticated projects where it is critical that data is correct, this method takes a large amount of time and effort.

This method of delivery often requires numerous clarifications, which are ultimately the sole means of communicating with the design team aside from site or prebid meetings. Although this method tracks the questions being asked and the answers being issued, it is usually too cumbersome to navigate in a relatively short period of time to provide an effective means of project communication. Often, the big issues are addressed, and smaller issues that aren't understood are interpreted and assigned a contingency to be resolved later.

Type of Documents

The typical documentation for design-bid-build is printed sheet drawings and specifications. The practice of providing the contractor with a PDF, CAD, or image file has become more commonplace, and estimating programs such as On-Screen Takeoff, SOFTakeoff, and Bluebeam can speed up this tracing process. Contractually, however, the design team is not typically responsible for sharing digital files and often doesn't—to limit any involuntary editing or further possibility for misinterpretation of information. Although the estimating software saves time, this system relies on the estimator to quantify accurately all the building components in a set of drawings and assign prices and estimates to the labor, equipment, and materials associated with that construction, using the architects' and engineers' design drawings for accuracy. Although this is the typical responsibility of the estimator, the issue of time continues to come into play. The reasons for this are that in a design-bid-build delivery, the architects and engineers have been working and coordinating drawings for much longer than the contractor, who typically has only weeks to fully understand the site, systems, construction, and reasoning behind the design before assigning a cost to the project. Although much of the project's estimate basis might be determined by a square-foot cost and subcontractor input, there is a large margin for error because of the lack of time to fully understand the project and all of its nuances.

Clarification of Information

Clarifications are formally issued and addressed in addendums that include supplemental drawings from the architect or engineer, specification clarifications, and other directives. These clarifications are then distributed to all contractors bidding on the project via email, fax, project website, distribution list or public notice. Additionally, these clarifications must be tracked and audited as to when they were issued and that all bidding parties received the clarifications. Again, in this type of delivery, the contractor and subcontractor have no input in the actual design and documentation process, with the exception of clarification and supplemental drawing information and are ultimately responsible for checking with the design team, owner or owner's representative to verify receiving any further updates.

Once the contractor has created an estimate for the project, the contractor's bid is based on the information provided by the design team and often carries a contingency to allow for information missing from the documents that is later resolved in the field. In this type of project, CAD drawing information is to be built as drawn by the architect and engineer. Because of a lack of flexibility, this process leaves little room for adjustment during construction, which may lead to an adversarial relationship between the designers and the contractors performing the work. The reason for change orders often involves the contractor's requirement to construct something that may be considered unbuildable as drawn. Another reason is that the contractor might have means of building something more efficiently than what was drawn by using new technologies, past experiences or new tools that the design team wasn't aware of when they were creating the documents. While this change may equal a price deduct, a change order will need to be issued to address this change. This lack of flexibility may equal additional costs when local jurisdictions having authority (JHA), standards and governing building codes require a certain type of construction that the contractor may have been aware of and that the design team might not have been. As the drawings and specifications in the design-bid-build method are the sole means of communicating exactly what is to be built, when situations arise that weren't thought about in the design and documentation phase, the contractor issues a change order. This is because every item that wasn't assigned a cost in the initial construction documents is considered "in addition" to original project scope and leads to extra costs. That said, incorrect documentation and lack of collaboration equal more costs, change orders, and inefficiencies in this delivery method.

Project Closeout

At the end of a design-bid-build project, the CAD files, shop drawings, specifications, RFIs, and change orders are compiled into a binder and submitted with a operations and maintenance (O&M) manual. These documents are submitted to the building owner after the final walkthrough and the completion of construction work under contract. This usually marks the end of the responsibilities for the contractor.

Often the O&M information turned over to the facility manager is an inadequately organized mixture of disconnected information. The facility manager is then tasked with inputting additional information or layers of relevant information over this compilation of disconnected data. This information includes tasks such as work orders and maintenance requests, move orders, associate locations, telephone extensions, equipment warranty information, emergency exit strategies, and any site-specific facility information such as laboratory clean rooms, hospital head walls, sensitive government data, and so on. The CAD files delivered to an owner are usually unreferenced or part of the architecture firm's legacy information, which might involve customized plug-ins, applications, and routines that are unable to be opened by the new facility manager.

This delivery method can drive a wedge between architect and contractor, especially if the construction documents aren't precise enough to cover work included in the contractor's contingency. This delivery is a perfect example of an old way of thinking, using a rigid system of information management and sharing, where the main focus is to avoid litigation. The architect is responsible for documenting all work to be completed on the project. Total documentation, especially through CAD, is nearly impossible in any project, and too often time is spent drafting details and views to prevent misinterpretation, as opposed to staying focused on the design and the owner's desires and requirements for the project. BIM in this model can be used little, aside from efficiencies realized by the engineers and architects using it to better coordinate their design documents and some use by the contractor for quantity extraction. Additionally this method promotes the separate creation of a construction BIM used in the field, which is developed by the general contractor separate from any construction documents and holding no design professional's sign or stamp. This in turn creates additional liability, which will be discussed in detail later.

Design-Build

The Design-Build Institute of America (DBIA) says this about the design-build method of delivery:

> *The design-build form of project delivery is a system of contracting whereby one entity performs both architectural/engineering and construction under one single contract. Under this arrangement, the design-builder warrants to the contracting agency that it will produce design documents that are complete and free from error (design-builder takes the risk). The selection process under design-build contracting can be in the form of a negotiated process involving one or more contracts, or a competitive process based on some combination of price, duration, and proposer qualifications. Portions of the overall design or construction work can be performed by the design-build entity or subcontracted out to other companies that may or may not be part of the design-build team.*

—*An Introduction to Design-Build*
(Design-Build Institute of America, 1994)

Many envision design-build as the BIM solution. Design-build delivery *is* much more integrated than design-bid-build and with the introduction of a design assist agreement, can create a strong foundation for collaborative practice. The design-assist agreement dovetails into a typical design-build contract and allows for the contracting team to have early involvement in a project, with a concession for the potential to recapture the fee when the design portion ends, if not selected for the project.

Although the DBIA holds no specific BIM contracts currently, it does strongly promote the early formation and collaboration of project teams. This might change as more owners, and specifically those who most often utilize the design-build form of agreement, demand BIM. Ultimately, the framework of design-build is structured to facilitate the use of BIM. However, some of the typical project deliverable timelines will need to be shifted to facilitate creating BIM documentation as opposed to CAD documentation to facilitate the new resources and tools available to construction managers to deliver a better project.

Preconstruction

In design-build delivery, the contractor or architect is contracted as a single entity known as the *design-builder* or *design-build contractor*. The purpose of this type of contract is to increase accountability and have a single source of project delivery. In this type of system (Figure 1.6), the design-builder is responsible for streamlining the process by combining the design, permit, and construction tasks. If the lead is the architect, the contract is for a "design-led design-build" project. If the lead is the contractor, the contract is for a "contractor-led design-build" project. In either case, both parties are under agreement to design and construct the owner's building in budget and on time.

The rising popularity of design-build shows it to be one of the more effective ways of delivering a project. However, there can be inaccuracies and ambiguities in this process because the construction can happen in parallel with the completion of the design documentation. The process is weak in design review because the design is still being completed as the project is being constructed. Quality control tasks associated with the design team become secondary, because the primary goal becomes completion of the project under a contractor-led agreement. The quality of design produced by the architect and design team can suffer as well, because the contractor's responsibility of coordinating trades and schedules on a working construction site becomes the driving factor for the project, not aesthetics.

Conversely, in an architect-led design-build project, there is the potential for the focus to become the aesthetic and design elements of a project instead of the project schedule or other construction-related tasks. A fundamental issue with a design-build project is that ultimately one project team member has seniority over the other by default. The fact is that whether it is the contractor or the architect, by choosing one or the other, the project team is not all on a level playing field, which can ultimately lead to project complications later. Design-build's efficiencies are in overlapping the design phase with the construction phase to shorten schedule and reduce project costs. To efficiently use the design-build delivery, you need a balance among the team members, built upon a schedule that enables the use of BIM processes. Remember that BIM is not necessarily a fast-track means of delivering a project. Rather, it is a technology that allows for more coordination before the project is constructed due to streamlined documentation processes.

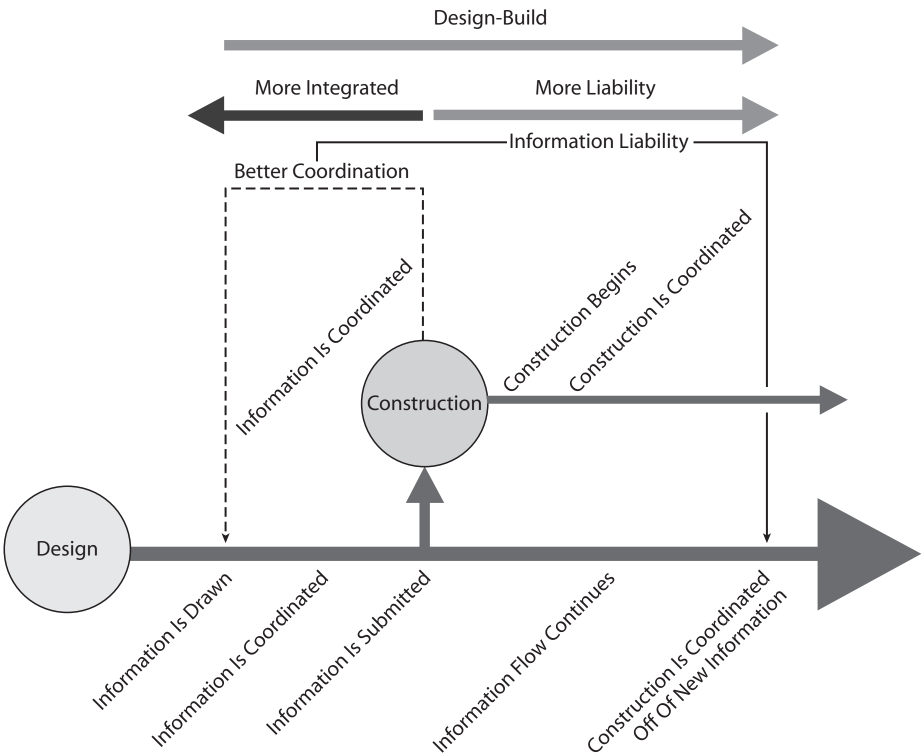


Figure 1.6 Design-build information flow

Communication and Collaboration Methods

Information flow in this type of project delivery begins with the initial design produced by the architect, as presented to the owner for review. This design is then used by the contractor to begin putting together an estimate and schedule for the project. As many architects and contractors know, the first design is rarely the one chosen and built. So while the contractor is assigning a cost to the first design proposal, the design is already outdated and incorrect; the architect is now revising the design per the owner's design changes and contractor input. This continues throughout the project process, because the architect is constantly trying to stay ahead of the contractor and the contractor is trying to catch up to the architect's design drawings.

The construction documentation phase of a design-build process often begins with 50 percent of the construction documents going to local code authorities to secure a permit. Construction planning and site development begin at this point in anticipation of 100 percent of the drawings being finalized. The mechanical, electrical, and plumbing engineers' drawings, as well as the specifications, are submitted in tandem with these documents. Engineers in a design-build contract are contracted directly with either the architect or the contractor and typically engage the design at the design development level of the project and in some special cases during schematic design. The engineers then begin to create their layouts, complete calculations, and size equipment based on the architect's design. The contractor then begins to assign costs to the engineers' layouts as well as the architect's drawings, while simultaneously beginning construction on the project. The construction of a building while design documents are being completed is unique to a design-build process. For example, allowing for the construction of certain packages of work, such as concrete or steel, requires careful coordination with the designers and engineers to make sure that as their designs are being completed they don't alter or interfere with work already being done. Although this is an opportunity for BIM to shine in this type of delivery, it is also a challenge to constantly update the composite BIM with new information from the architects and engineers.

Types of Documents

In a typical design-build project, documents include printed construction documents and specifications, CAD files, and PDF files. In a design-build agreement, CAD and PDF files are readily shared, because the team is responsible for building the project together; as one benefits, so does the other. For this reason, the formality and rigor of document sharing are reduced when compared to the design-bid-build means of delivery. Sometimes, because of the sensitive nature of a firm's legacy data, the architect or engineer will require a media release or a nondisclosure agreement to be signed by the project team. This is a means of protecting the firm's database of information from being shared with competition, either intentionally or unintentionally. Many firms deal with company-specific digital information by printing the drawing information into a hard copy or PDF and then deleting the native files from the shared documents in order to avoid any issues.

The same agreement might be required if BIM is integrated into this type of delivery method and specifically if the general contractor has an in-house design department but is working separately from that department on a project. A BIM type of project documentation can be planned for and coordinated in a design-build process and should be introduced in the initial contract negotiation meetings. Chapter 2 discusses how to build and integrate an information exchange (IE) responsibility plan and a model coordination plan. Both of these, or similar documentation, should be required in a design-build project if the intention is to use BIM in any fashion on a project.

Clarification of Information

Changes in this process are addressed with cost updates. The preliminary contracts usually provide for design alterations and changes throughout the design and construction documentation process. Typically a point of no return takes place in the project, after a final budget has been issued, when design alterations stop and further design changes result in additional project cost or change orders in the field.

Conceptually, design-build aims to limit the exposure of uncoordinated items and, through collaboration, increase the viability and accuracy of the project. Yet this process also relies heavily on the integrity of the contractor to deliver the project within budget and schedule, which may be difficult because the quality and interpretation of design documents leaves room for misinterpretation and assumption. Although not all design-build projects are fast-track or require additional construction and design coordination, many times the project is similar in timeline and schedule to a design-bid-build delivery, with the major exception that the project team is integrated. A rising perception within the industry is that—just like cheaper isn't better in a design-bid-build project—faster isn't better in a design-build project. In actuality, the more coordination and clarification that can be accomplished before a shovel ever touches dirt, the more potential issues can be avoided later.

Many times in design-build the engineering team provides a performance specification. It is then left to the subcontractor to design and build a system that meets these requirements. Many subcontractors are familiar with this and go about designing and issuing shop drawings for engineering approval. Yet some companies have seen a unique opportunity. Because they ultimately design the mechanical, electrical, or plumbing system and build it, there has been a rise in companies integrating engineering in-house and offering both services. By streamlining internal processes between the engineer and the fabrication shop, many of these companies are becoming more popular, specifically among more integrated teams, because of the coordination they can offer.

Project Closeout

At the completion of a project using design-build, the O&M manual is issued, along with hard copies of the building drawings, shop drawings, field changes, specifications, change orders, and punch lists. This information is not in a connected format and often is a hybrid of paper and digital documents, just as in other delivery methods. It then becomes the responsibility of the facility manager to correlate this information into usable documentation.

BIM in design-build presents a unique opportunity by allowing facility managers to define early on what they expect to see as a deliverable at closeout, not only the type of documentation but also the level of detail within the documentation. The buzzword of *digital O&M manuals* pertains to the concept of embedding within BIM components relevant and specific information. Information such as cut sheets, photos, shop drawings, pictures, and URLs can potentially be inserted or linked to model components (see Chapter 7). Combined with a more integrated means of delivery, design-build offers unique opportunities as a delivery method for BIM projects.

Design-build is the father of a true BIM process. It introduced the idea that a project team that collaboratively seeks to complete a project can realize efficiencies and profits. Design-build delivery continues to be a good starting point for those interested in beginning integration one step at a time, as well as a means of building a BIM process through hybrid documentation.

Note: It is always important to consult with legal counsel prior to engaging in or using altered or untested contracts, agreements, and plans. Although the examples in this book aim to further define what tasks are important in a BIM process, you should always review all documentation with your legal counsel.

CM-at-Risk

CM-at-risk entails a commitment by the construction manager to deliver the project within a guaranteed maximum price (GMP). The construction manager acts as consultant to the owner in the development and design phases (often referred to as *preconstruction services*) but as the equivalent of a general contractor during the construction phase. When a construction manager is bound to a GMP, the fundamental character of the relationship is changed. Not only does the construction manager act in the owner's interest, but the construction manager must manage and control construction costs to not exceed the GMP, which would be a reduction in fee and as a result a loss in profit.

> *One of the most important aspects of the survey results is the changing attitudes concerning construction delivery methods. Quasi-public and government organizations predominantly use the design-bid-build method, but clearly, many have tried other methods and most would consider either CM-at-risk or design-build to be the best-value alternatives. Changing the delivery methods used, in the case of these organizations, will often require changing laws and politics, but that is happening, too, because the public is best served when it gets the best value for its tax dollars. Privately held and public companies continue to try a variety of delivery methods...but CM-at-risk will likely become the more dominant delivery method for this group as long as the experience is positive.*
>
> —FMI/CMAA Sixth Annual Survey of Owners (FMI, 2005)

CM-at-risk delivery methods can be customized to a BIM process. CM-at-risk as a BIM process has two key ingredients. The first is that there is a belief in the industry that a more integrated process equals a more profitable one (Figure 1.7). The second ingredient is a perceived value in leveraging BIM technology with the team.

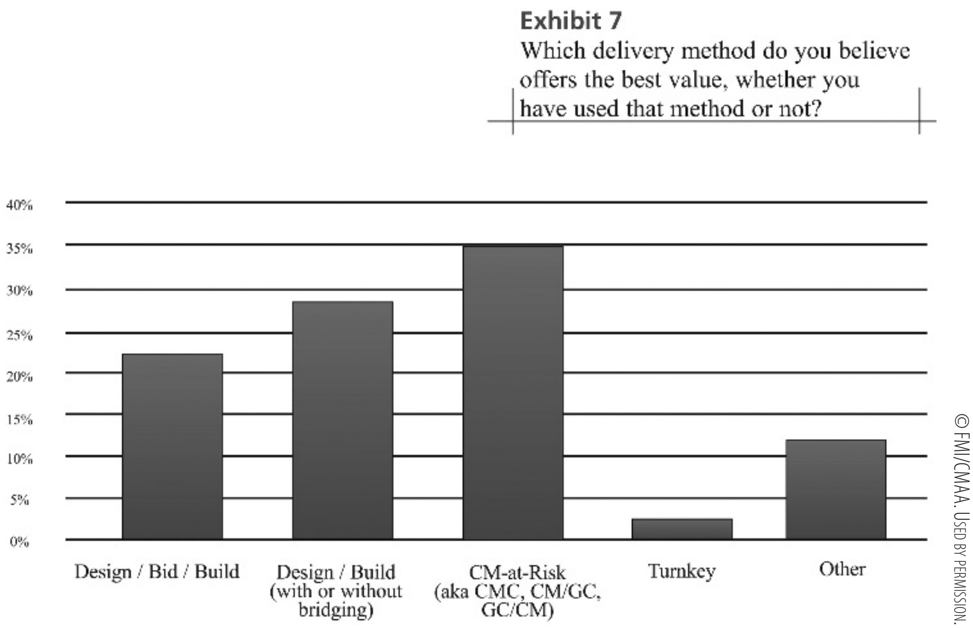


Figure 1.7 Perceived delivery method value

Preconstruction

The flow of information in a CM-at-risk contract can provide an integrated service. By *integration*, I mean the ability for the contractor and subcontractors to be involved with the project very early on and have input into the design and documentation of a building. The CM-at-risk model puts the risk for delivering the project at the proposed GMP on the contractor's shoulders and thereby gives the contractor a stake in the development of the project. What is valuable from this type of delivery is having the contractor sitting at the same table as the design team.

During preconstruction, the CM's involvement is critical to the success of this type of project delivery. The contractor can continually inform the design team of cost based on the current documentation. Using a design-to-budget approach, the contractor removes the value engineering period associated with project delivery methods that typically come in over budget. *Value engineering* is the belief that by allowing time for the design team to redesign a project to attempt to reduce cost, the changes made will save the project money. This concept is flawed; as a process, it indicates only that proper estimating procedures were not in place prior to the design being completed.

Although this process is prevalent in design-bid-build and even some design-build projects, the CM-at-risk delivery method somewhat mitigates this issue because the contractor is intimately involved with the estimating process of the project, because they are required to deliver a GMP based on the completed design.

Communication and Collaboration

The contractor in this method is responsible for delivering the project within the budget. The architect who contractually may be under the contractor or the owner, while attempting not to exceed the project budget, may deliver a project that programmatically and aesthetically pleases the owner. The risk to the owner in CM-at-risk is the contractor taking too much control of a project, especially when the contractor enters the realm of design and owner program management. If the project is difficult and unique in design, a construction manager may become concerned with the cost and difficulty of the project. By providing estimates and updating material costs, the CM enables the owner to make a decision based on the aesthetic or the cost and move forward without damaging the project timeline. The real issue for this type of project delivery is making sure there is an involved owner in the process to see that both the design and the cost requirements are being met.

Ultimately, the contractor is responsible for delivering the project on time and within budget. However, that shouldn't come at the expense of good design and project balance. By seeking project balance and collaboration in the flow of information and management of the project, CM-at-risk can effectively utilize team integration and BIM technologies. With proper up-front coordination and planning, the CM-at-risk delivery method is an effective means of bringing all team members to the table and sharing responsibilities equally among them.

Type of Documents

The typical documentation for a CM-at-risk delivery is printed contract documents. Again, because of team integration and depending on team agreements, PDFs and CAD files may be made readily available. As the design develops, the need to continually update the estimate may affect the means of transferring data. In some cases, a project FTP is established, or a means of drawing distribution is established through either a print shop or plan distributor. In other cases, the drawings may be simply emailed through a point person who tracks and archives the files that were sent for future reference.

In this delivery method, the need for agility and rapid transfer of data is primed for BIM. Using a composite model, multiple design changes can be housed in a single model and can easily be imported to replace antiquated data, which can then be archived. BIM holds an enormous advantage over CAD in this type of delivery. The three-dimensional construction of a facility inherently holds quantitative information that may be used early in the process to establish a preliminary estimate and coordination. In addition, the cumbersome management of multiple singular drawings or CAD files associated with each profession for each update can be overwhelming, whereas a BIM is a single file to update that contains all the necessary information relative to that profession.

Clarification of Information

The process of clarifying information with a CM-at-risk delivery is integrated and project focused. Clarification during preconstruction involves direct interaction and input from the general contractor and even subcontractors. The contractor is able to clarify a number of issues, including budget, estimate breakdown, trade coordination, and constructability. By providing a GMP for the project, the contractor has a vested interest in providing the design team with as accurate of information as possible. Likewise, the architect and engineers have an obligation to the contractor to provide as much information as possible along the process of design development to further refine the scope, budget, and schedule of the project.

During construction, the contractor is typically very pliable and, instead of taking an adversarial approach to issues that arise, takes on a mediator role. This is because profitability is directly tied to the contractor's performance and project coordination. While bidding to subcontractors, if required, the contractor and design team have it in their best interest to give the subcontractors as much information as possible about the project to improve the accuracy of the estimate and to reduce any large contingencies. Although many of the issues should be resolved prior to construction because of integration and team involvement, there exists the potential for a general contractor to receive an additional bid for a scope of work if they believe the estimate to be too high.

BIM fits well into the CM-at-risk method of delivery. The BIM tools available allow for the ability to test and coordinate prior to construction, thus limiting the need for clarifications. Yet if clarifications are needed, BIM provides the ability to quickly find answers, which is critical in a CM-at-risk project where large amounts of data are being frequently moved.

Project Closeout

At project closeout, the owner receives information just as in the other methodologies. The facility manager is again responsible for coordinating all the documentation, information, and correspondence as part of the job. In some cases, the facility manager is brought to the table early and defines what the expectations of project closeout deliverables might be. This early interaction should also be written into the project contracts as required deliverables for the project, because otherwise the facility manager is left with the same jumble of information as with other methods.

Often facility managers are hired after the completion of the facility and are not as familiar with the facility as the project team and owners. Therefore, the flow of information and project experience are disconnected. As a best practice, construction managers should ask what type of deliverable is expected at project closeout for a number of reasons—first, to define the cost and resources needed to deliver the documents, and second, by being prepared and asking, the construction manager averts dissatisfaction from the client and provides the new facility manager with the requested data.

A New Concept of Delivery

Integrated project delivery (IPD) is a new form of project delivery that has gained popularity as an integrated solution. Although many firms have practiced integration, this new definition of project delivery and contract language aims to take it to a new level.

> *Integrated Project Delivery (IPD) is a project delivery approach that integrates people, systems, business structures and practices into a process that collaboratively harnesses the talents and insights of all participants to reduce waste and optimize efficiency through all phases of design, fabrication and construction.*
>
> —"A Working Definition—Integrated Project Delivery"
> (AIA California Council, 2007)

Preconstruction

IPD calls for a complete integration of teams from the onset of a project, allowing the team as a whole to become a collaborative group that focuses on leveraging the latest technology to foster flexibility and successful project outcomes. This delivery method has really started to set the stage for a truly collaborative process. Although varying degrees of a BIM process can be used in virtually every delivery method, this method allows for a greater degree of potency in the process and promotes project balance through the required use of BIM. George Elvin makes an excellent case for integration and spells out how it's critical to the success of the industry.

> *Pioneers in integrated practice are finding they can amplify their fees, expand their services, and build long-term relationships with their clients by working in a highly collaborative relationships with all project stakeholders throughout the complete lifecycle of the buildings they create.*
>
> —George Elvin, *Integrated Practice in Architecture* (Wiley, 2007)

Communication and Collaboration Methods

By integrating BIM technology and using new delivery methods that focus not only on the successful delivery of the project but also on project balance, rewards are achieved in the form of profit, professional relationships, reputation, and money. A fundamental flaw in all the previous delivery methods is value added vs. project cost. In most scenarios, the project team is reimbursed as a percentage of the project cost. This quantifies in some way the scope of the work to be performed by the project team. The flaw is when a member of the project team or the project team as a whole improves collaboration and creates value or savings for the project. This results in the following:

- There is no incentive for the AEC team to create any additional value, because there is no additional compensation for the additional resources required to further collaborate.
- If the professional's fee is based on a percentage of the project, the fee may be reduced for the professional because of significant project savings.

IPD promotes the concept that by sharing the risk and reward of a project through target project goals, that compensation may increase or decrease depending on results. As an example, the team, including the owner, develops a goal for the entire project budget. If the project comes in under budget, then additional fees are distributed to the team; if the project comes in over budget, fees are reduced. By holding the others accountable, IPD fosters a great degree of communication and promotes intense collaboration among the project team, because it can result in additional profits.

This delivery method involves the entire project team from very early on in a project and consists of project goals, which are shared and incentivized throughout the team. By using the knowledge of *all* parties, including subcontractors, consultants, and local governing bodies, IPD aims to eliminate issues in the field that result in significant cost overruns later in the project. Through increased accountability and promoting teamwork, IPD is a model for new process teamed with new technology.

Nelson-Atkins Museum Addition, Kansas City, Missouri, constructed utilizing BIM technology. Photo by Brad Hardin.

Types of Documents

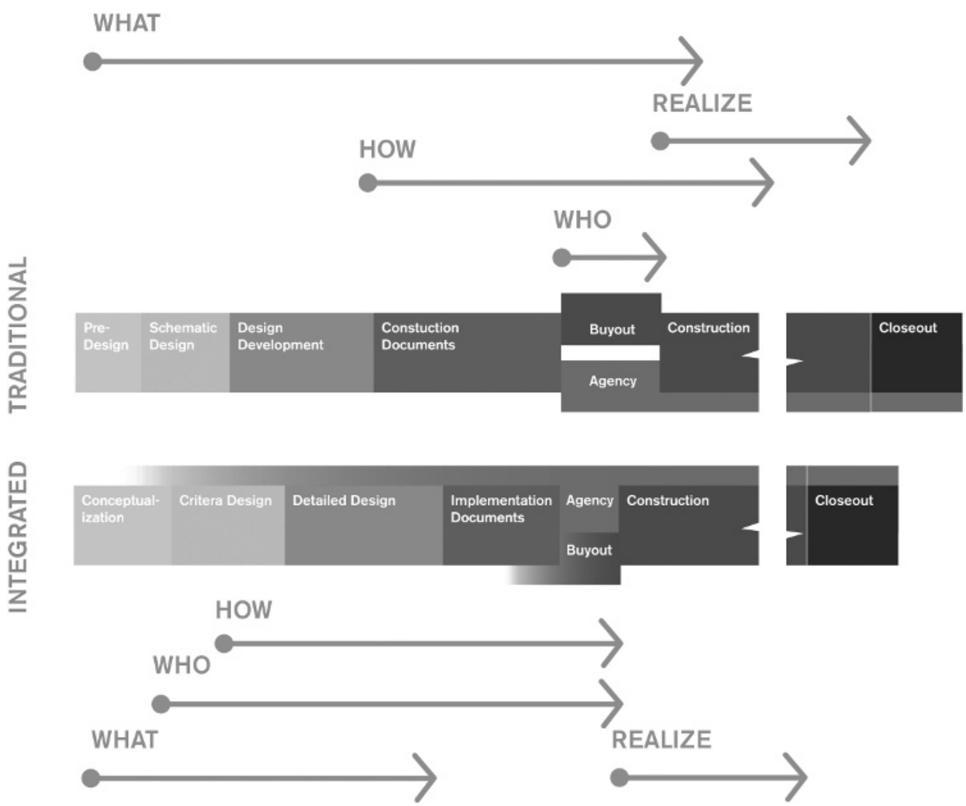
IPD is unique in that it is driven by BIM technology. IPD relies on BIM not only to be more collaborative and integrated but also to be a quick and efficient means of developing a project. With BIM, a change to one element equals a change everywhere;

this means that the technology is limber enough for a design to be developed, tested, altered, and updated during preconstruction to eliminate coordination issues later.

Documentation in an IPD process is a combination of individual profession-focused models, such as the architectural and engineering models, and the composite BIM documentation. This BIM documentation can be used for estimate revisions, constructability reviews, clash detection, site coordination, and a host of other coordination responsibilities. Because many changes can be represented in one model file, the number of information transfers is reduced, but the information is able to be tested and coordinated more quickly than in CAD.

Clarification of Information

Information flow in an IPD process (Figure 1.8) continually informs the team and allows the project stakeholders to have a say in the project and make informed decisions as a whole. The advantage of this type of information management is that the biggest focus of the project now becomes using and sharing information. It is no longer the litigious arena that architects and contractors have played in for decades but rather a new platform that effectively challenges the knowledge base and experience of a project team by making the focus understanding and early issue resolution, as opposed to profession-focused concerns.



"A Working Definition—Integrated Project Delivery" (AIA California Council, 2007).

Figure 1.8 Integrated project delivery

Project Closeout

Integrated project delivery provides the stage for all the team members to perform at their best. IPD is unique in its ability for the facility manager to be involved with the construction and design of the building and ultimately to use BIM as a tool to better maintain the facility. Information sharing and data management techniques are refined to make an integrated project successful. A completed BIM at project closeout avoids the typical disconnected data and provides the facility manager with a much more useable tool than CAD. Other documentation still must be compiled either digitally, embedded in the model itself (see Chapter 7), or embedded in an O&M manual.

A New Concept of Process

For decades, the way data was transferred in a construction process was linear, with one task being followed by another. This old process of drawing collaboration involved a large number of isolated files that needed to be continually updated and constantly managed. In a typical CAD process, information was created in isolated CAD (or other) files and then digitally inserted over the top of the floor plans, sections and other separate views. For example, the architect would reference a single mechanical floor plan file of a single floor and use the single structural engineers' CAD drawings for a single floor as a background to test for conflict interference between the two. This process was time intensive, not automated, and cumbersome to review in a project with frequent updates.

In the old system of information management, documentation was updated by deleting or archiving CAD files and then inserting the updated drawings over the top of the new files. A disconnection of information often happens here. For example, say the architect has to redesign a wing of a hospital or the owner decides to move 30 percent of a building's square footage into the next phase of their building plan to stay within the budget. A lot of work is associated with these kinds of changes. The architect now needs to send out updated plans and other drawings to all of the MEP, structural, and civil engineers. Subsequently, these engineers must redraw any items that directly influence their trades. As drawings are completed, they are redistributed back to the architect. Now there is more coordination, not only between the architect and the engineering team but also between the plumbing engineer, who needs to know where the new plumbing mains are to be routed from the street, and the electrical engineer, who needs to know, because of the lighting changes, if they are now hitting the bottom of the redesigned ductwork in the system. There are lots of possibilities for coordination to be missed in this process, especially with tradespeople, who might not be specifically thinking about the other trades' responsibilities within an area. This coordination of information silos is the first big area for concern of the old system of information management.

The second area of concern is the time it takes to reconstruct and update information. How long will it take the architect to now overlay the MEP drawings and go through the new drawings with a fine-tooth comb to find any conflicts as well as get their own drawing tasks accomplished? It is often a monumental task that only gets worse the more complex the building and more demanding the client's needs, budget, and occupant requests. In addition, this cuts into the profits of the design team, whose fee was based on a specific scope of work.

Where Does a Contractor Fit in a BIM Process?

The contractor should be considered a member of the design team, allowed not only to manage construction but also to help manage the information that is being communicated in order to build the facility. I am not suggesting that contractors take the place of architects or engineers but rather that they be considered just as valuable a member of the design team as the architects and engineers.

The main purpose of construction documents is to communicate the design intent to the builders from the architect. In the past this process has been linear; in this new type of process, the information is sequential: one event defines the event that follows, and then that defines another event and then another. The model is a way to virtually construct, test, change, and communicate design intent in a way that wasn't available to the construction team before. Thus, BIM informs designers so they can make better decisions about their designs. Conversely, it allows the contractor to determine the means and methods the contractor anticipates using to build their visions as well as provide a contractor's perspective on the design. The reward for the contractor being engaged in the construction documentation or the implementation of the documentation phase is that it provides everyone on the team with insight into the actual construction of the project. In a BIM project, while the drawing/modeling time is front-loaded, the size of the staff and the amount of time required to model the project are both reduced. The big idea in a BIM process is not only the ability to store information within the model but also the ability to communicate better. For example, using a 3D rendering during design to coordinate a piping layout makes for more informed decisions using the model.

If you start to think of the model as a virtual construction of the finished product, the question becomes, how many ways can this information be used to help the design team from a contractor's perspective? This book gives specific examples of integrating BIM in estimating, site coordination, construction coordination, enhanced schedule visualization, phasing, trade coordination, clash detection, sustainability issues, improved in-field communication, 3D shop drawings, and facility management models that go beyond making the case for BIM, but rather define a whole new level of virtualization.

Using BIM also inherently improves communication. Where before we could see lines on a light table or overlaid on a computer screen, now we can see in a 3D view. Before BIM, projects consisted of coordinated plan, elevation, and section information to understand the building; now we can create sections, elevations, and perspectives quickly in real time because they are all different slices, views, and projections of the virtually constructed model.

Integrating project teams before project delivery also promotes team buy-in. As opposed to the adversarial relationships that could potentially develop between team members, a truly integrated process limits potential litigation in a BIM-focused process. The contractor understands the design intent more fully than before, as well as feeling that they have used their knowledge of construction to further inform the design team about decisions that involve actually building the design. Another great aspect about BIM is that it reduces contingencies. According to Michael Kenig's article "Beyond BIM: Spending Money to Save Money" (*Constructor*, September/October 2007), on average 1 percent of a project's cost is spent on resolving non-owner-initiated changes. He goes on to say that with the use of technology-enabled coordination on a project, BIM can reduce contingencies and increase the return on investment in BIM by three to four times.

Integration using technology permits the contractor and subcontractors to be familiar with what is to be built. In addition, the contractor can clarify the scope and budget earlier in this process, prior to bidding or construction. Ultimately, a contractor's knowledge, experience, and input is more valued and utilized in a technology-applied integrated process than in any other means of delivering a project.

Is BIM a Fad, or Is It Here to Stay?

The people asking whether BIM is a fad are not asking whether BIM is the way the future of design and construction is headed but are rather asking, how much will I have to change? and how much will I have to learn? As new technology continues to emerge, it's good to ask questions about software and applications with regard to the best way to implement these new tools and whether they are right for your use. Don't avoid BIM technology because you are not comfortable with change. We live in a world that is constantly changing and adapting. New technologies are a direct result of that constant change, and many companies see BIM as an opportunity to make themselves more profitable and implement tools that owners, new employees, and contractors enjoy using. The fact is that the industry is not racing back to drawing lines in CAD or even creating hand-drawn line drawings, as beautiful as they are.

The reality is that the productivity loss in the construction industry because of inadequate coordination equates to about $60 billion a year, according to Michael P. Gallaher, Alan C. O'Connor, John L. Dettbarn, Jr., and Linda T. Gilday in *Cost Analysis of inadequate Interoperability in the US Capital Facilities Industry* (NIST, 2004). This, combined with the exponential growth of BIM in the job market (Figure 1.9), begins to paint a clearer picture of the need for both technology and people who can better coordinate construction projects.

Figure 1.9 Job listings calling for selected skills

Technology and time are two of the biggest threats to the successful completion of a project. Rapid developments in technology make for dependence on everything from cell phones, emails, software and equipment to better coordinate projects. If these tools don't work, it makes it very difficult. Secondly, time is critical to any construction project. A good construction manager knows time is important and uses all available tools to ensure a project's successful delivery. But, technology and time are also the biggest potential advantages. Specifically, the use of technology over time develops, creates, and refines tools for its users. Technology rarely goes backward. Technology continues to move forward at a blistering pace. The use of BIM has been no different. Within the past decade their have been huge strides in BIM technology, which have equated to a significant rise in users. These industry professionals have "spoken with their pocketbook" as to the value of BIM. Specifically in the construction industry, many companies see the investment more than worthwhile and use it to market themselves against competitors.

Although many remain skeptical about BIM and BIM-related technologies, you need to ask whether you are being the most productive and profitable that you can possibly imagine. If the answer is no, then it's apparent something needs to change in order to make it that way. To that end, I strongly suggest investigating BIM.

Ten Steps for Successfully Implementing BIM

What does it take to implement BIM? When you start down this path, you have to ask some questions. What are you trying to achieve with BIM? What elements define this company? And what steps are necessary to begin implementing BIM software and processes?

To begin, develop a simple statement about how BIM aligns with the goals of the company, how it can be used in the future at the company, and how it might make your company more successful. This brief statement should define the organization's stance on new technology. This will become vital information later, in the implementation phase, when the pieces of software that have been identified by the organization to implement might go beyond BIM. Additionally, ownership needs to be involved in this initial discussion of strategy, because they will have to decide on investments in software, hardware, and staff.

Ten steps are critical to the successful implementation of BIM in any organization, outlined in the following sections.

Step 1: Identify a BIM Manager

When a construction company embarks on constructing a structure, the organization staffs a project manager to direct and organize the project. This is the same in virtual construction. Similar to a construction manager, a BIM manager must manage and facilitate all the processes necessary to create and manage BIM. This involves coordinating all the information from architects, consulting engineers, and subcontractors. The BIM manager also coordinates project reference points and develops a schedule that identifies when tasks such as clash detection and model updating need to take place. Overall, the BIM manager needs to have old skills, new skills, and, most importantly, an open mind and ability to solve problems. In his article "The New 'Must Have'—The BIM Manager," Dominic Gallello outlines the responsibilities of a BIM manager as follows:

- *Understanding project workflows (schematic design, design development, construction documentation phases) and project management.*
- *Understanding different needs of the delivery team (architects, engineers, estimators and contractors). The BIM Manager works much earlier with the entire project team in setting up the project structure and data exchange formats.*
- *Technical knowledge of the BIM application used, related systems and network infrastructure, and awareness of new technologies.*
- *Communication and training skills (verbal and written).*
- *Strong teaching and coaching skills to bring new team members up to speed.*
- *Ability to communicate the benefits of BIM firm-wide, including the "personal win" at each level in the organization.*
- *Objective decision-making in times of crisis.*
- *Flexibility and mobility. Large multinational firms with multiple offices worldwide often require BIM Managers to help the implementation of new company standards throughout the whole company. In addition to a desire to see the world, being sensitive to cultural nuances will be a great asset.*

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Many companies choose to start the process with a single professional internally—someone who has good management skills and who has a background in technology. This is wise, because the best person for this job needs to have an intimate understanding of the day-to-day functions within the company. If this resource must be a new hire, then it is critical to choose an individual who is highly competent in organizational and communication skills, has a background in BIM technology, and can be trained in different pieces of software and to manage multiple tasks.

This BIM manager becomes a key player in the next nine steps of implementation. Before selecting the BIM manager, consider the manager's involvement on other projects, because the implementation process is time-consuming and will become the sole initiative of this individual. This person needs to be able to understand the functions of the software and how it will work with the company's operations. In addition, it will be the responsibility of this BIM manager to spearhead the process of integrating BIM into the company. The goal of the BIM manager is to identify what will work best for the company and make recommendations to the leadership about what is valuable and what might not be the best fit or might need to be further developed.

Step 2: Develop an Estimate of Cost and Time to Implement and Use BIM Software

The next step is to put together a software and hardware acquisition plan. This plan should include the cost of the software, the hardware, and any additional staff needed. The goal of this plan is to give management an idea of the scale of the investment needed. It should include yearly subscription costs, support costs for at least the first year of using the software, and any other costs associated with using the software. Potential hardware costs include additional RAM, disk space, servers, or network connections that are required. The software vendor can generally furnish this information.

The following is an example of a line-item estimate for one user to begin using BIM with an extremely robust set of tools:

Equipment	Cost	Time Period
Dell Precision M90, with additional memory and enhanced graphics card	$2,400	
Microsoft Office tools or equivalent	$300	
Architectural CAD/BIM modeling software	$3,200	First year
Structural or energy analysis software	$1,000	
Estimating software	$7.200	
BIM model compiling software, such as Navis	$9,300	
32˝ HDTV LCD monitor (optional)	$1,200	
Video projector (optional)	$600	
FTP site service provider annual charge (optional)	$1,900	
All software's annual service charges (subscriptions)	$1,200	After first year
CAD training charges	$6,000	

Equipment	Cost	Time Period
IT cost for initial setup	$2,200	
Dedicated large-format plotter/printer and service charges	$2,800	
Annual salary of staff	$70,000	Annually
Cost of attending industry events such as seminars, trade shows, and peer group events	$4,000	
Grand total	$112,100	

Although this example shows a full-blown, robust BIM machine, training and software, you should keep it in perspective. BIM is an investment and requires a significant cost; on the other hand, the potential savings and return on investment far outweigh the costs of hardware and software, and can be purchased over time.

Because many of the pieces of software require additional horsepower to make the software function correctly, this can make for a significant investment by the firm. Further development of the plan should include a description of each piece of proposed software, a rationale for its use, the cost, and estimates for the time to implement it and train personnel on its use (see Figure 1.10).

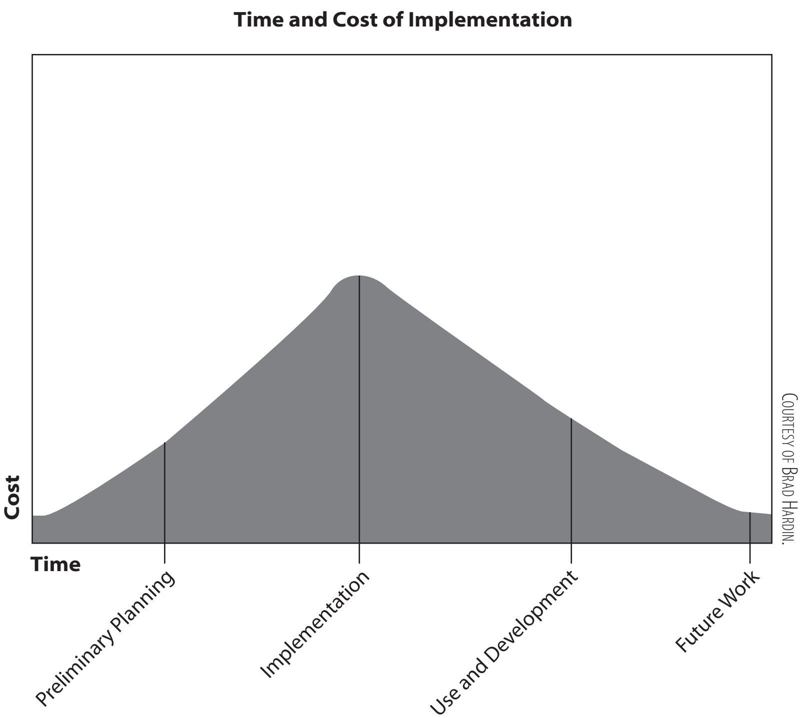

Figure 1.10 Time vs. cost of implementation

Implementing a BIM solution is an endeavor in itself; to make the overall transition easier, a firm should not try to acquire and train people on multiple pieces of software at the same time. Identify specific pieces of software in the estimate that show the initial investment and time, and show what software is to be acquired later in the integration plan.

The goal of the acquisition plan is to give management a clear understanding of the total cost to implement the proposed solution and to secure ownership buy-in. Ownership may begin a conversation about which software products can get the firm to walk in BIM before everyone has to start running in it. The BIM manager should rely on the experience and guidance of management and senior staff to help develop a plan that everyone can support.

Step 3: Develop an Integration Plan

The implementation plan consists of a software acquisition plan, a training schedule, a hardware update schedule, and a narrative explaining the company's shift into this new technology. Additionally, the implementation plan explains how the BIM strategy will be rolled out across the company. This plan will take time to build, so account for this.

For larger organizations with multiple offices across multiple states and a large employee base, it's best to start with a single office that can become the hub for the system. You won't gain anything by attempting to implement BIM at two or more locations at the same time. The BIM manager needs to research and interview the different departments to find out what software is currently being used as well as what processes are in place in the organization. Often it is helpful to list the software and the departments in a spreadsheet to analyze what existing software is BIM compatible.

For smaller companies, take inventory of what is currently being used, and then develop a plan based on division interviews. See what tasks are required, and how long they will take for each division.

Put metrics in place. The goal is to determine the efficiency of new systems as a benchmark. Eventually the production of metrics after adoption should show efficiencies of the new system compared to older tasks.

Step 4: Start Small

Training should begin with the BIM manager and a few dedicated associates from the division specified in the implementation plan. The idea is to begin with a small group that can start producing work after their training. The first group's goal is to start using the software and implementing it immediately after training on a project. Unless the use of the software directly follows the training, the associates will forget what they learned.

Five Components of an Integration Plan

An integration plan has five components:

Synopsis This is a brief statement of the company's stance on BIM.

Goals and schedules This section should include all of the following:

- Goals of the BIM integration
- Purpose of the BIM integration
- Team members' responsibility outline; should include new and changed responsibilities
- Software acquisition plan, which should show the following:
    - Training schedules
    - Hardware update schedules
    - Implementation schedule

Additional operational information This includes new contracts and new delivery methods.

Future growth plan This should outline the future goals for BIM at the company.

Supporting articles This should include journal articles, publications, book excerpts, and statistics that make the case for BIM and identify potential opportunities.

When completed, the plan should be compiled into one document and then presented to management. The BIM manager will be responsible for implementing the plan and organizing the training for associates, and it is critical that division managers know that training will be taking project management's time away from their normal day-to-day tasks. Organizing the management of associates and scheduling their training will be challenging, but the rewards, if implemented correctly, are significant.

The next issue involves project choice. Smaller projects provide a scalable way to begin using software effectively, while in a larger project the fee is able to fund research and the purchase of the software. Larger project BIM implementation isn't necessarily to pay for the software; it is to create efficiencies and savings for the project team and the construction company. The size of projects varies, and there are pros and cons to each. This decision will need to be made by the team and will need to be focused on a project where the architect, engineer, and fabricators are all using BIM.

Step 5: Keep the Manager Trained

The BIM manager will need to be trained in all the BIM software that the company uses—not to become completely proficient in all these different pieces of software but rather to gain an understanding of its purpose and be able to competently speak about all the software when requested to report on its implementation. Continuous training will keep the company aware of new technologies, methods, and resources through the manager.

Step 6: Support the Manager by Starting a Department

Implementing BIM in a construction company is in many ways more difficult than in a field such as architecture or engineering. Although an architecture firm might adopt Revit, Bentley, or ArchiCAD, the BIM implementation in a construction company goes through each department and involves multiple pieces of software and overlapping responsibilities. In a typical architecture firm, the role of CAD manager is usually filled by the professional who has been tasked with maintaining firm standards, implementing software, and keeping the licenses up-to-date. In a construction company, the role of BIM manager is specific to each company. Because there is no general consensus about the specific role of the BIM manager and supporting personnel such as BIM specialists, there seems to be a number of companies that have identified that the number of projects within their organizations requires a BIM department. In a construction company, a BIM department should be structured so that the average workload can be distributed effectively among the team. Typically, BIM specialists can run about three to five projects, depending on their experience level, while a BIM manager might be able to handle more. Don't expect to hire one BIM manager and have them effectively run 12 or 13 projects. Think of the construction project manager's project load and staff similarly for the virtual construction department. Because the project manager is responsible for the physical construction, the BIM manager will be responsible for the virtual construction and inform the team about issues before construction on the project starts.

Step 7: Stick to the Plan but Remain Flexible

Possibly the most difficult part of implementing BIM technology at a company is sticking to the plan. This entails supporting the manager, purchasing software on schedule, and making sure associates are being trained in software relevant to their day-to-day tasks. The implementation is successful when the plan is achieved.

Although sticking to the plan is a yardstick for success, it's also important to be flexible. The implementation process can potentially take years, and it's important that the plan stays flexible as new software and other technologies become available and other challenges arise. Software will continually change, so the plan has to adapt to better alternatives that become available as key milestones are reached.

Step 8: Create Resources

Develop internal tutorials and guides. Developing tutorials will help create a reference and a learning point for field personnel, construction management, and other departments. In turn this will create a lean BIM department and the ability to standardize how certain tasks are accomplished. These tutorials may be hosted on a company's website, intranet, FTP or other media for access.

Step 9: Analyze Implementation

Find out how BIM is either improving or not improving processes. Measure to see what components of BIM are realizing the most savings and creating the most value. By measuring where the BIM implementation plan has taken the organization, the manager and the leadership team can gather information and begin to analyze which software is working and where there is room for improvement. It is critical to the success of a BIM division that you avoid pointing fingers. BIM is a growing industry, and certain solutions continue to be tested in the real world. There are so many pieces of software and so many organizations operating with different standards in place that BIM solutions must be customized to complement a company's existing operating platform—that's yet another reason why research is critical, as stated in step 1.

Step 10: Monitor New Software Proposals and Industry Trends

The BIM manager has to constantly be immersed in market trends, new software, and industry publications to stay ahead and aware of industry trends:

- By staying aware of new and emerging solutions, you can begin to develop a plan in your mind that addresses issues at your own company. Constantly question the efficiency of an operation, and continually seek improvement.
- Management will often become interested in what technologies can give them a competitive edge over their competition as more and more owners and clients begin to request BIM technologies. Many companies adopt multiple pieces of software to try to achieve a desired result, but the real market advantage comes with being able to show how a solution has worked (or not) and to learn from the experience.
- This BIM department has the potential to generate revenues outside an organization's bread-and-butter revenue source. One of the advantages of integrating new technology is that by doing so you can create a product that becomes more intelligent and useable by professionals along the path of construction. Sometimes markets are created, just as virtual construction companies have begun to explore what the value is to create a BIM, something that wasn't even considered until recently.

Additionally the BIM Manager should attend conferences, presentations, forums, and construction meetings related to BIM technology to do the following:

- Learn how others are using each piece of software and, in turn, get the message out about the company's experience with these solutions.
- Gather information from these groups and functions to take back to the team.
- Remain aware of new available technologies and get an idea for emerging market trends to make more informed decisions later.

Technology today is moving at an exponential pace. Software development, entrepreneurship, and global communications technologies have created an environment in which being cutting edge requires someone to constantly be informed. A number of online resources are available, such as blogs, content libraries, online model testing sites, and forums. A few are listed here:

`www.revitcity.com`

`www.augi.com`

`www.bimforum.org`

`http://bimcompletethought.blogspot.com`

`www.aecbytes.com`

I encourage professionals to share and distribute among their peers the procedures and best practices that educate users about BIM. The dialogue becomes stronger among the BIM community and becomes an invaluable resource to build upon for the present and future generations.

By staying aware of the market and emerging developments, the BIM manager will be able to make more informed decisions about future implementations as well as be able to judge a company's current status compared to the market.

Ten Steps: The Short Version

This sidebar comes from the advice I gave a colleague who was tasked with implementing BIM at his organization. Although it's a humorous slant on the ten steps, it's meant to outline a recipe for successfully integrating BIM into the fabric of a company.

1. BIM doesn't work—people make it work. There is no way you can load BIM onto a machine, plop anyone in front of the machine, and hope that it will somehow make your life easier. In fact, it will make it harder for a while; let everyone know this.
2. BIM is an investment. The easiest way I can explain this is that it's almost like your 401(k) in the form of coordination return. Will you realize the profits immediately? I don't know—probably not. Will you realize your investment six to eight months down the road when you find 188 clashes that equate to more than $2.3 million in change orders? That's closer. Will you realize that investment when you can provide a greater service to your AEC team in improved communication and collaboration? Bingo!
3. BIM will not tie your shoes. I use this phrase in my office when someone thinks that BIM can solve every construction-related problem there is. It's just not true. BIM is still developing. There isn't a "one-software-works-for-everyone-and-will-fix-everything" solution.
4. Start small. A colleague of mine was recently tasked with integrating BIM into his large construction company. He gave me a call and asked me what the best methodology was. He was thinking of training all 16 different satellite offices via web meetings. I told him don't. Start with one office, make it work, and go from there.

Ten Steps: The Short Version *(Continued)*

5. Train yourself. Make sure you know and learn and continue to learn as much as you can.
6. Start a small, intense training of a BIM team. These will be your disciples and your backbone when you get uber busy. Believe me, it happens.
7. Third, multiply yourself. Create an FTP file where you can put all of the information in your head in the form of tutorials, articles, standards, etc. for everyone to refer to. This will make your life easier as well.
8. Stick to the plan but don't. After you've dedicated three weeks to do nothing but write a plan that includes a schedule and key timelines, and made it generous, be prepared to edit it frequently. People will question why the company is implementing this new strategy. Be prepared to be called *overhead* until you make their day-to-day routine more efficient—and then be prepared to be called *buddy*.
9. Stop and look at what you've done. Get management to review the implementation, and get feedback so you know where to improve. Finally, get some metrics. This will be a little like herding cats, but finding out how BIM has helped or hurt each division will help your decisions.
10. Attend conventions, seminars, and technology expos to learn about what's out there and if it could be helpful to your company. Have a committee that reviews the new stuff and presents a software plan annually to the ownership.

When new technology and software are approved to be implemented, repeat....

Conclusion

BIM is not perfect. It is a relatively new technology when compared with other industry standards. Yet BIM is the greatest technological advance in the AEC industry in this generation. BIM software was developed as a response from design professionals who began to see the need to create a single source of information that can be shared, added to, altered, and responsibly distributed among the design team. We are just beginning to see the full potential of BIM both as a process and as software and what it means to harness its full capabilities. Although these needs will begin to be addressed as the industry acceptance of this new technology and resource grows, everyone must contribute their ideas, criticisms, and suggestions to the industry. We need to understand that as an industry we are a progressive and creative group of professionals who ultimately are playing in the same arena. As construction professionals, we have an obligation to future generations, to the environment, and to improve BIM technology.