Part 1

Fundamentals

Although this book is focused on helping you master Autodesk® Revit® software, we recognize that not everyone will know how to find every tool or have a complete understanding of the workflow. The chapters in Part 1 will help you build a foundation of essential knowledge and may even give veteran Revit users some additional insight into the basic tools and concepts of building information modeling (BIM).

- **Chapter 1: Understanding the Principles of BIM**
- **Chapter 2: Exploring the UI and Organizing Projects**
- **Chapter 3: The Basics of the Toolbox**
- **Chapter 4: Configuring Templates and Standards**

Chapter 1

Understanding the Principles of BIM

In this chapter, we cover the principles of a building information modeling (BIM) approach within your office environment and summarize some of the many practices used in today's architectural workflows. We explain how you and your organization can achieve some of the many possible benefits from BIM by sharing the processes that these technologies support. As you will see, these practices are oriented to industry BIM uses that provide advantages such as more thoroughly explored design concepts, better coordinated documentation, and better executed construction methods.

In this chapter, you'll learn to

- Focus your investment in BIM
- Understand a BIM workflow
- Leverage BIM processes

The Fundamentals of a BIM Approach

Building information modeling is an integrated model-centric methodology that delivers validated and coordinated knowledge about a building project throughout planning, design, construction, and operation. When this collaborative, interdisciplinary approach is optimized, it can improve an organization's operations. BIM provides designers, contractors, and owners with a process to improve decision-making, quality, and timeliness. At the core of this BIM approach are model-centric workflows (geometric and data models) that support project execution and asset lifecycle management. These workflows determine the methodology for creating data-rich geometries, integrated deliverables, and a model-based process to develop projects from planning through the operation and management lifecycle phases. BIM can be defined through technology, processes (its governance through standardization), and people. The technology system is central to the processes of creating, storing, and using models. With processes, the success of BIM requires all stakeholders in the project ecosystem to follow a series of steps, both as individuals and as a team. Ultimately, the users of these techniques and technologies are committed to improving their design process by successfully integrating both geometry and data.

To succeed with these practices in this environment, a business must make fundamental changes in the way it operates, whether by moving into a new market or by changing its methods of operation. It requires an alignment of the organization's activities relating to its people, processes, and technology with its business strategy and vision. Through collaboration and data management during an asset's lifecycle, sharing information efficiently and effectively can support better integration and interoperability among all project stakeholders. Along with this data comes the possibility of integrated analysis. By making these analyses easily accessible, derivatives of this model-centric workflow can provide a better understanding of design opportunities and decisions' consequences. With the availability of valid geometry-based data, 2D, 3D (visualization, clash detection), 4D (time), 5D (cost), and beyond are possible. Taking advantage of these capabilities is a must in keeping architecture firms relevant in today's market. Transforming your organization's business quickly and efficiently will be the difference between maintaining your market share and taking that next evolutionary step forward.

The Management People Inside a BIM Project Team

The architectural marketplace is changing and is influencing staffing decisions as skills needed for BIM projects can be different than traditional CAD skill sets. Some of your organization's leadership may be aware of this change and are organizing BIM teams and resources to better anticipate new processes. Others are unsure of how BIM may change how they plan projects, from staffing to hiring. When looking to acquire BIM-skilled staff, savvy firms look for process experience in their new hires and no longer solely focus on hiring those with tool expertise. The primary factor is always professional experience, but knowledge of a BIM workflow supports these professional skills very well.

When planning project staffing, architecture firms generally focus on deliverables produced by a project hierarchy of managers, designers, engineers, interns, and draftspeople. BIM roles and responsibilities are based on the availability within the project team, rather than composing the best fit based on model-based workflows. This does not constitute a project problem as much as it decreases efficiency in two ways.

- Roles/responsibilities are not clearly defined, and team members must adjust to BIM project needs during the project. Managers, who are making staffing decisions, may not have the resources to judge BIM experience level or tool/process skill sets, other than hearsay or previous project experience with similar circumstances.
- BIM managers have a better understanding of these capabilities but do not generally make staffing decisions for projects. There may be project managers who know to confer with BIM managers over this need at project start-up; however, this is uncommon.

Typically, professionals are hired based on project experience, education, and certifications. Historically for architecture firms, BIM experience was considered as nice to have but not required. In today's market as BIM and BIM skills have become commoditized, an increasing number of professionals have BIM experience on their résumés in the form of project experience and trained tools, as BIM skill sets are being required more frequently. Not having these skill sets does not preclude new staff from being successful BIM project team members, but it does impede the ability of managers with BIM experience to staff projects appropriately and hinders their ability to develop a plan in accordance with project requirements.

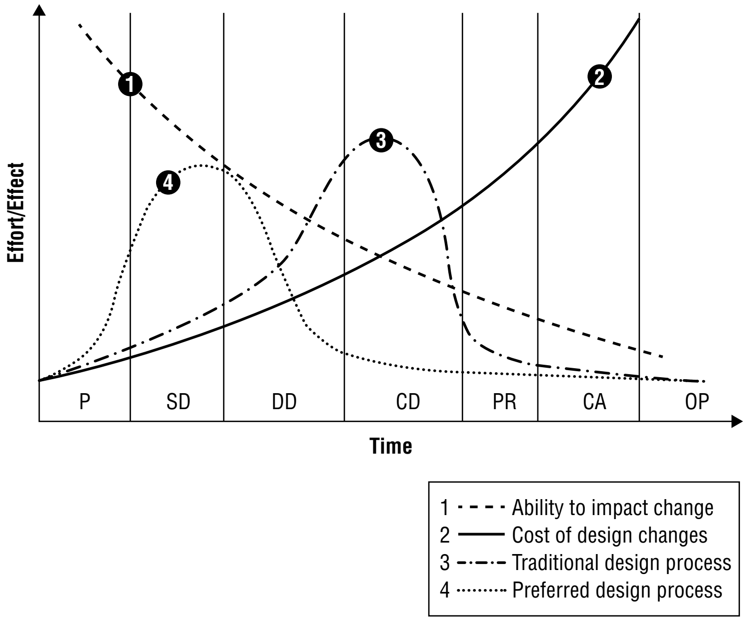
Regardless, whether you are making staffing decisions or are a hardworking BIM project team member, understanding how these workflows are changing the planning and execution of projects is important. Being prepared by understanding the people, processes, and technology of BIM is a must.

Staffing for BIM

As the building industry's process of design and documentation is transforming, one of the fundamental changes teams need to address is staff planning in a BIM process. A common misconception of project management is that staffing the BIM project will be the same as it has been in CAD workflows. Unfortunately, this is not the case. Because a BIM-based project can significantly alter the project workflow, which now includes BIM-focused goals that are beyond simple documentation, many of the standard timetables for task completion are no longer valid. (See Chapter 8, "Managing Revit Projects," for further details.) Although fundamental deliverables remain the same (drawings, schedules, etc.), the processes to reach these outputs are different. For example, in a CAD workflow a user can create a plan as a single one-off entity. In a BIM workflow, the same user must develop a model before a floor plan can be produced. The investment in the 3D model requires more time upfront, and therefore the floor plan to be produced necessitates a longer schedule. However, once this model has been produced, many other derivatives can be produced with less effort. As a model is developed, the ability to generate accurate and precise drawings, schedules, and analysis is made expedient because it is derived from the developed model. To leverage this workflow, the staff and processes must take into account the gathering of momentum early in the cadence of execution to accommodate all phases.

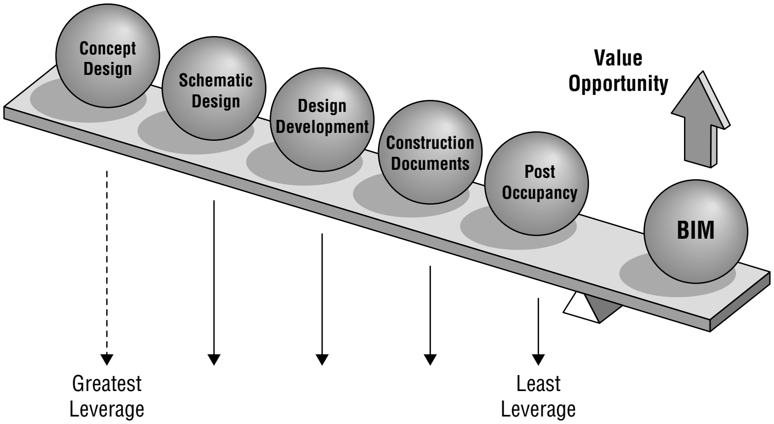
Years ago, Patrick MacLeamy, who was then CEO of Hellmuth, Obata, + Kassabaum, explained this workflow movement with a diagrammatical description of the shift of workload and the ease of affecting change in the construction process forward. The graph, which has come to be known as the MacLeamy curve (Figure 1.1), is not simply intended to imply a shift in labor earlier in the design process; rather, it stresses the importance of being able to make higher-value decisions earlier before changes become too difficult or costly to implement. The x-axis of the chart represents project phases from conceptual design through occupancy, whereas the y-axis represents the amount of effort in each phase.

Figure 1.1
The effort curves in the design and construction industry



Another important aspect of a BIM workflow is its ability to leverage decisions earlier in the process. As shown in Figure 1.2, implementing BIM in earlier project phases allows teams to make and share better information earlier so that the entire project team can benefit earlier. On the basis of the BIM uses, a common industry term that we will refer to later in this chapter, project teams may need to adjust labor in the planning and design stages to support the development of the geometric and data model. In a CAD workflow, different project roles may be tasked with separate tasks in order to move the design forward. A planner may be developing a program, just as a designer may be producing massing studies. In a BIM workflow, these roles may be continuing the same task but in the context of a single model allowing them to interact through geometry and information. Because of this interaction and its ability to allow better decision-making, project teams may be deploying additional staff to help support this collaboration in BIM. Depending on the BIM uses, teams might increase staff to build a model or to perform energy analysis; however, deploying a BIM workflow will not necessarily provide more proficiency or quality than a CAD-based project without proper planning and governance.

FIGURE 1.2
BIM provides more leverage when it is implemented earlier in the design.



Understanding Project Roles

It's also important to understand how the significant changes to tools and processes provided by BIM affect the roles and responsibilities of the project team. Project managers need to plan staffing and labor required to complete tasks in every project phase. BIM projects are supported by a few primary roles that will allow the team a level of predictability, although the specific effort and staffing will vary between offices (and even projects). Here are the primary roles that should be considered on every BIM project:

Design Architect Generates design intent from the planning stage through early design

Technical Architect Produces the deliverables, ensuring the design intent is achieved

Coordinator Directs the BIM workflow between design and production

These roles represent efforts and general tasks that you need to take into account on any BIM project. For larger projects, these roles could represent multiple people, whereas smaller projects might constitute the same person filling multiple roles. For many architecture firms, designers and production staff may be tightly integrated and have few differences in the responsibilities. For other firms, there may be a clear demarcation between the first two roles. Regardless of the interaction between designers and production roles, every BIM project has some coordination responsibilities. We will next explore each of these in more detail and discuss how these roles affect the project workflow.

The Role of the Design Architect

The role of the design architect is to generate the design intent, typically focused on the project from pursuit through planning to design development. These staff may include licensed architects and interns. Designers typically interact with the BIM process by first transferring their conceptual ideas into digital form. For many planners this is going from two 2D layouts to a 3D model. For more sophisticated designers it might be to create a conceptual massing model based on sketched geometry or something as sophisticated as iterative design calculations. Whatever the case, designers are the origin for models of the project.

For some workflows, designers may stay in a more traditional process, and technical architects begin the BIM process based on their designs. As creative processes and digital capabilities align, designers moving forward are more likely to use digital authoring tools for their work rather than traditional ones, such as hand sketching and physical modeling. With this, the BIM process will start earlier in the project timeline. Following this workflow, designers have the capability to make better decisions for the project team earlier based on the intelligence they provide to their geometric-based designs. What becomes most important at this stage is having a workflow specific to design work in BIM projects that allows creativity but properly sets the stage for production staff to develop the designs into buildable instructions. With this in mind, the typical responsibilities for design architect include

- Create initial design intent models through the creation of 3D geometry through conceptual massing or iterative design processes.
- Lead the creation of architectural elements and building from within the model.
- Design around code requirements and other building logistics.

The Role of the Technical Architect

The role of the technical architect is to ensure that the project is buildable. These staff can be a wide-ranging group from experienced licensed architects and architectural technologists to interns who are learning how buildings go together. As with design architects, technical architects have a role in the BIM process not because of their professional skill sets but because of their responsibilities to the project workflow. As models are developed, technical architects solve issues such as constructability, wall types, and managing the program of spatial and equipment requirements, as well as other issues involving code compliance and client relationships.

Primarily concerned with deliverables, production staff manipulates models to create the needed outputs, such as drawings and schedules. The role of these staff is to create sheets and embellish associated views with annotations or other details. This role applies standards to the project (as in wall types, keynotes, and so on) and organizes the document set. Technical architects are responsible for the bulk of the work needed to document the project. In earlier stages of the project, this role is typically assumed by either the architect or the modeler, but as documentation progresses into later phases of design, this can quickly become the role of multiple people on a larger project. This role includes the following tasks:

- Validate the constructability and detailing aspects of the design.
- Produce project deliverables from well-coordinated models.
- Follow the established Level of Development (LOD) or Model Development Specification (MDS) to ensure models comply with requirements of the stated BIM uses.
- Ensure the models and valid data are passed to construction and operation phases of the project lifecycle.

The Role of the Coordinator

BIM coordinators supervise the overall project modeling techniques and discipline-specific BIM output through all project phases. They are responsible for checking that all models produced by design and production staff comply with the standards set out by the BIM project execution plan (PxP). They check that models are correctly named and are the current version and that all relevant asset metadata has been completed with appropriate values. They coordinate requests for supplier information from the design teams and determine whether model details already exist in the library of design objects. Where model components do not already exist, they create or delegate their creation in the context of standards and set responsibilities. Their BIM duties are to

- Author and maintain the technical sections of the PxP.
- Determine project file organization and model splitting strategy.
- Define file sharing protocols for the project.
- Determine team training needs and organize training if needed.
- Assemble and maintain any multidiscipline models.
- Manage publication of files.
- Create project delivery output from assembled files matching all the firm's BIM standards.
- Review models for adherence to project standards.
- Maintain the team's access to the correct tools for BIM authoring, aggregation, and analysis.
- Oversee the application of BIM technologies and ensure that the model adheres to all internal and client-specific goals and standards.
- Oversee the development of the content of a specific model element to the LOD/MDS listed for a particular phase of the project.
- Assist all team members in BIM processes at all stages of the project.
- Lead 3D coordination meetings.

These BIM roles for architectural project teams generally work for most firms and building types; however, it is ultimately up to each organization and its management to decide how team members share in the responsibilities of managing geometry and connected data specifically for its needs. As long as there is an expectation set at the beginning of the project and a workflow defined during its phases, any number of roles and responsibilities should help ensure that the project is completed successfully. In support of that, project managers have a responsibility to help maintain the integrity of this workflow. Although they may not be directly developing models, they are making important staffing decisions based on this workflow and have the responsibility to ensure that the deliverables from this process meet contractual obligations. With that, we suggest that project managers have enough knowledge of BIM people, processes, and tools to do the following:

- Understand the impact BIM has on a project delivery schedule.
- Allocate time as planned for BIM management activities for the BIM coordinator and any BIM administration and support requirements.
- Be familiar with BIM concepts and uses on a project so that they are able to effectively manage the project team and communicate progress and requirements to the client.
- Oversee the administrative and contract sections of the BIM project execution plan.

Establishing a BIM Execution Plan

To optimize your results with BIM, you need to start with the end in mind. Although a lot of tasks are possible with BIM, before you draw your first wall, you will want to create a BIM project execution plan. We go into more detail about creating these plans and some resources for them in Chapter 6, "Working with Consultants," but essentially a BIM plan helps to drive the direction of the modeling effort and modeling outcomes. How will your consulting team share models? Will your project need to provide BIM deliverables such as a reference model or databases in the Construction Operations Building Information Exchange format? Does the owner have expectations for a model deliverable for operations and management? All of those possibilities and more are explored and documented in a PxP. It gives the project team a definitive outcome to develop and enrich the models.

Creating a standard BIM project execution planning process will help project teams to plan and execute the required processes to achieve the anticipated goals. Using a PxP template and a planned methodology, the project team members should actively pursue these concepts:

- All parties should clearly understand and communicate the strategic goals for implementing BIM on the project.
- Teams should understand and communicate their roles and responsibilities in the project execution.
- The plan should outline resources, training, or other competencies necessary to successfully implement BIM for the intended uses.
- The baseline plan should provide a goal for measuring progress throughout the project.
- The plan should provide a benchmark for describing the process to future participants who join the project.

Teams carry additional process risk when implemented by teams that are not experienced with the BIM process, as many team members, managers and users alike, are not familiar with the strategies and processes of this workflow. If the process is well planned and communicated, the project team will set expectations of what is to be done and how, thereby reducing the overall risk to the project. To ensure a successful project execution planning process, the team should do the following things with the PxP:

- Modify the plan to meet the project's needs.
- Build the plan with the entire consulting team.
- Create an LOD or an MDS with the entire consulting team to facilitate model and staff planning, unless it is already required by the owner.
- Review the plan early and often, making needed changes as project experience grows.

For those of you who are responsible for developing the PxP for your team, begin your plan by referencing industry-based templates, such as the Penn State Project Execution Plan or the Autodesk BIM Deployment Plan, that can provide you with shortcuts to a well-organized and consistent PxP process. Determine what is needed by your project teams and then modify the plan to match your requirements. Additional language specific to the type of facility and construction should be added to the plan to make it more appropriate. A comprehensive PxP should include these sections:

- Statement of project goals and objectives
- Intended BIM uses
- Team structure and deliverables
- Roles and responsibilities
- Data transfers
- Phase-based data requirements
- Intended authoring, analysis, and aggregation tools
- Governance information

By doing these things, project teams should have no problem developing a comprehensive project execution plan that will benefit them on a daily basis.

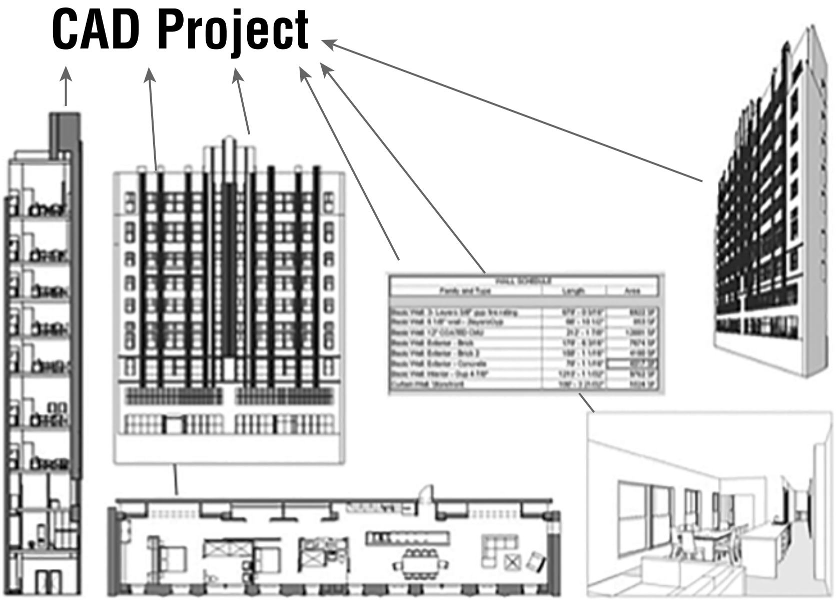
Optimizing BIM Processes

According to the National Institute of Building Sciences (`www.nibs.org`), BIM is defined as "a digital representation of physical and functional characteristics of a facility" that serves as a "shared knowledge resource for information about a facility forming a reliable basis for decisions during its lifecycle from inception onward." Although this is the definition of the noun used to represent the electronic data, the verb form of building information *modeling* is equally important. BIM is both a tool and a process, and one cannot realistically exist without the other.

Building information modeling implies an increased attention to more informed design and enhanced collaboration. Simply relying on tools to replace your current processes without an updated corresponding methodology will yield limited success. In fact, it may even be more cumbersome than using traditional CAD tools to execute project work.

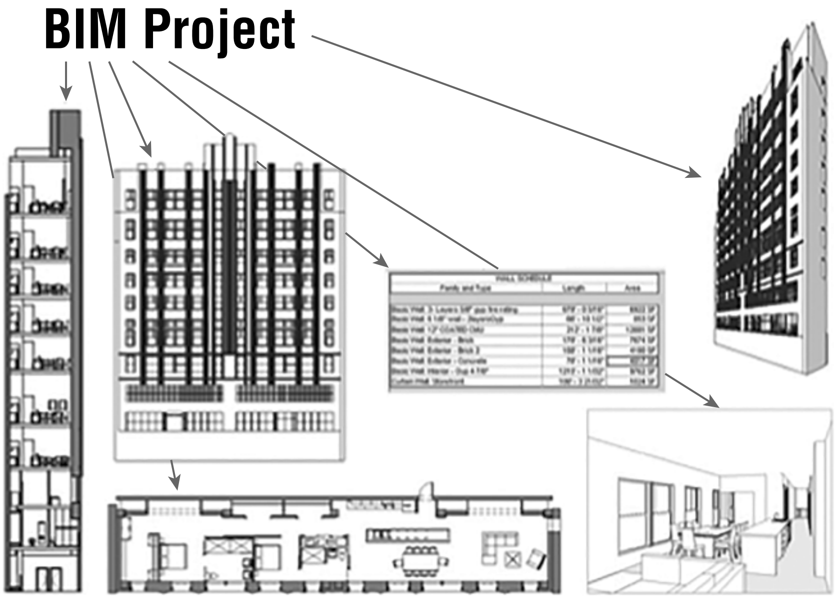
Regardless of the design and production workflow you have established in the past, moving to BIM is going to be a change. Moving to BIM is a shift in how designers and contractors approach the design and documentation process throughout the entire lifecycle of the project, from concept to occupancy. In a traditional CAD-based workflow, represented in Figure 1.3, each view is drawn separately with no inherent relationship between drawings. In this type of production environment, the team creates plans, sections, elevations, schedules, and perspectives as stand-alone entities and must coordinate any changes between these views manually.

Figure 1.3
A CAD-based workflow



In a BIM-based workflow, the team creates 3D parametric models to generate the drawings necessary for documentation and analysis. Plans, sections, elevations, schedules, and perspectives are all by-products of creating a building information model, as shown in Figure 1.4. This enhanced representation methodology not only allows for highly coordinated documentation but also provides the basic model geometry necessary for analysis, such as daylighting studies, energy usage simulation, material takeoffs, and so on.

Figure 1.4
A BIM-based workflow



Identifying and Planning BIM Uses

We encourage you to explore ongoing research from organizations such as Penn State University, buildingSMART International, and the UK BIM Task Group. Penn State (`http://bim.psu.edu`) has developed a catalog of BIM uses and project implementation guidelines that have been adopted into the National BIM Standard-United States Version 3 (`http://nationalbimstandard.org`). Another important aspect of supporting numerous BIM uses is the development of open standards. The organization known as buildingSMART (`www.buildingsmart.org`) provides a global platform for the development of such standards. The UK-based BIM Task Group (`www.bimtaskgroup.org`) is helping the region adopt BIM practices through building standards and educational support. Groups from a number of regional chapters around the world are generating information exchange standards that will soon have a profound impact on the ways in which we share model data with our clients and partners. The following are some of the latest developments:

- Industry Foundation Classes (IFC) version 4
- Construction Operations Building Information Exchange (COBie)
- Specifiers' Properties Information Exchange (SPie)
- BIM Collaboration Format (BCF)

For a general overview of the approach to standardizing exchanges with information delivery manuals (IDMs) and model view definitions (MVDs), visit `www.buildingsmart-tech.org/specifications`.

As the industry continues to build processes around the technology behind BIM, its potential continues to grow. Many applications are possible using building information modeling.

As more and more benefits are achievable through BIM, teams find new uses to explore and develop. Figure 1.5 shows some of the potential opportunities that have been identified by the AEC (architecture, engineering, and construction) industry and clearly organized by Penn State.

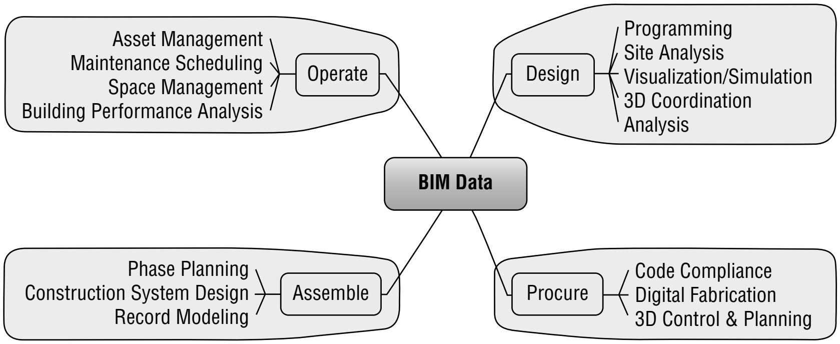


FIGURE 1.5
Service opportunities that BIM supports

When you are trying to plan and manage your organization's BIM and methodology, it's important to think about the use of these processes and technology to achieve your project goals. One of the primary ways of understanding this is through BIM uses. These many uses can be organized into five basic activities: gather, generate, analyze, communicate, and realize.

Gather To collect and manage building information

Generate To create information about the building

Analyze To examine aspects or components of the building to make better decisions about how to plan, design, construct, or operate it

Communicate To shared information about a building collaboratively

Realize To build or manage a physical element using building data

Understanding how benefits are derived from these uses will help focus your teams' efforts in planning, managing, and governing BIM processes.

Gather

As architects pursue work and plan awarded projects, they gather information about budgets, required functionality, site context, and anything else of significance that is required to make the best decisions for the project. In an analog process, this information may be gathered in the building program, a contract, or even a cartoon set of drawings required. The advent of BIM processes and technology is changing this. BIM not only allows the acquisition of smartly acquired contextual data about the project but also becomes an improved repository for information gathered in traditional ways.

One example of these traditional processes is the creation of the space program. Space programs are usually developed by interviewing user groups that are to occupy the building and gathering information about the things that they do and the equipment they need in the adjacencies of the spaces they occupy. These processes are collected in a spreadsheet or in graphical layouts that explain their qualities. This type of data is typically used in parallel with the design process, with many planners manually pulling information into computer-aided drawing (CAD) layouts. With BIM, this process takes on a more evolved approach to connecting design data to programmatic requirements. Using a BIM process, a designer can input spatial information directly into the model database even before conceptual massing or area plans are generated. This allows the designer to take directly from the program information to lay out a design and get instant feedback on whether it meets the required tolerances for these requirements.

Another example of gathering intelligent data could be in the form of laser scanning. There are sophisticated technologies that allow for the generation of point clouds for pre-existing spaces. The generation of these spatially located points can be used as an accurate underlay in the building of existing conditions. With millions of points available, designers have at their fingertips a massive amount of data in which to begin to understand the context of their designs. This has incredible applications for complex renovations or spatially challenged sites or even historical preservation efforts.

Through this kind of information gathering, the qualification and quantification of data can empower the design team to understand both the implicit and explicit attributes of its projects. These processes can also help support estimating and cost forecasting efforts. During the early design phases of a building, quantities may be generally estimated but become more certain as the contract documents are created and construction processes proceed. All along the stored information becomes more and more accurate with respect to design intent.

Toward the later part of the construction process and into operations and maintenance, processes can help establish real-time performance measurements within facilities to help owners understand energy usage, operation costs, and many other metrics. As an example, an integrated operations and maintenance (O&M) system may be tracking electrical costs on an hourly, daily, weekly, monthly, and yearly basis to help owners understand where they're maximizing their energy investments and where there is waste that they may reduce. Information gathering can be important throughout the entire lifecycle of a BIM project.

Generate

One of the most common aspects of building information modeling, and the one most accessible to new users, is the creation of intelligent geometry. As users draw a wall, a mass, or a new level, they are generating not only form but also data that helps them make informed design decisions. For example, when a wall is drawn in an authoring tool, that object can immediately have attributes such as length, width, and height. It may also have multiple materials, structural and finish, as well as cost and a fire rating. In a CAD process, the users must maintain the intelligence that they attribute to the objects they are drawing. They may be able to quickly generate four lines to represent a wall that could understand length and width, but that's where the distinction stops. These CAD drawings, although they can contain additional information, are inherently based on the output, whereas building information models inform the outputs rather than vice versa. A wall in a model database is the design. In CAD, the outputs represent what the users conceptually maintain in their mind. As smart as we are as architects, we can't maintain all the information needed to be communicated to the contractor in building our designs. That's where BIM can begin to support us by maintaining the information for us.

When users generate information about the project through both geometry and integrated data, they are prescribing attributes, arranging elements, and determining real-world dimensions. Within the context of the lifecycle of the building, the designers during the planning and design phases are the primary generators of geometry and data. During the construction phase of the project, the subcontractors will manage most of the data in the models. For sophisticated BIM projects, the construction phase management of as-built data can be created to build a foundation for the operations phase where that information could be used to operate and maintain the building. This database that they might maintain could be updated with new information throughout its entire lifecycle. This might include new equipment installed or renovations made to existing structures.

As experts generate both geometry and data for the project, they are specifying qualities and generating design data. The planner of a building may define particular spaces in the building, just as a structural engineer may define a structural grid. Later in the project, a contractor might define a specific construction sequence as attributes of materials, just as the owner's construction manager may define the need for a specific piece of equipment. Because all these ideas are generated inside the building information model or linked systems that influence this database, generation of building data can happen in every phase.

As designers make decisions about the spatial configurations of the building, they have a range of elements in three dimensions. This is the beginning of 3D coordination processes, which is a major asset to BIM practices in terms of collaboration and problem solving. This can begin with the arrangement of spaces; move to an arrangement of structural systems, through mechanical, electrical, and plumbing systems; and end with coordination of trades that are constructing the building. Because of all these aspects that occupy space and therefore have some relationship with one another, the model becomes a spatial organizer for this arrangement.

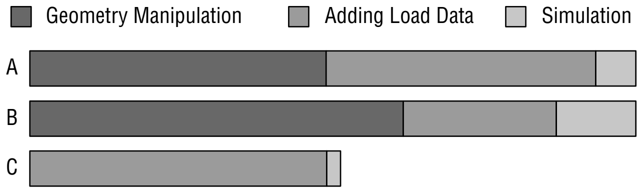
Before the opportunities that BIM provides, subcontractors could only determine technical issues with installations as services were being installed. This might include a piece of ductwork that does not quite have enough room to move around a beam or a doorway that does not have enough clearance from the edge of the stair riser. Because BIM provides the ability to simulate design conditions, the spatial coordination between designers, engineers, and consultants can be addressed prior to construction and installation. We now have the ability to find mistakes within a simulated environment and provide corrective actions during the design phase of the project. This ability to solve problems earlier in the arrangement of these three-dimensional objects affords designers and builders a great opportunity of designing better outcomes with much more cost-effective and timely solutions. In the end, it's much cheaper to fix it in the computer than in the field.

The sizing geometry also is an important aspect to the generation of information in these models. Just as spatial organization is important, the ability to estimate the correct dimensional aspects of building systems in the specification of specific equipment is important. Generating sizing information in a 3D model might take the form of creating types based on standard industry specifications. Being able to specifically model objects that have real sizes and tolerances helps designers be able to make the right decisions about specifying common building elements and complex building systems. Typical authoring programs have tolerances built in for the level of detail that's required to have buildings constructed accurately. Users have the capability of modeling much more accurately than they ever could in the field. Of course, the caution here is that teams need to realize that though they can be more accurate in the model, the ultimate purpose of the model is to get the building built and into operation efficiently and effectively. This means sizes should be based on the requirements of the construction trades; any more information or accuracy beyond that is not needed. However, where BIM shines above typical CAD processes is its ability to share truth. It is much more work to hide the true sizes than it is to display them accurately. This may frustrate some users who are used to applying their own dimensions, until they realize that the models represent what they designed, whether it is to a standard dimension or not.

Analyze

The primary purpose for the authoring environment is creation and not analysis. Because geometry and data are combined in a single database, confidence in that interaction allows us to begin to understand what it is and what it will create. This first step into analysis begins at the planning stages. However, it's common to pull information from the authoring environment into one specifically built for analysis. You'll find that many processes and tools specifically built for analysis work in parallel, and sometimes perpendicular, to model authoring. The real value in BIM beyond design documentation is the interoperability of model geometry and metadata between applications. Consider energy modeling as an example. In Figure 1.6, we're comparing three energy-modeling applications: A, B, and C. In the figure, the darkest blue bar reflects the time it takes to either import model geometry into the analysis package or redraw the design with the analysis package. The lighter blue bar reflects the amount of time needed to add data not within the authoring environment, such as loads, zoning, and so on. The lightest bar represents the time it takes to perform the analysis once all the information is in place.

FIGURE 1.6
BIM environmental analysis-time comparison

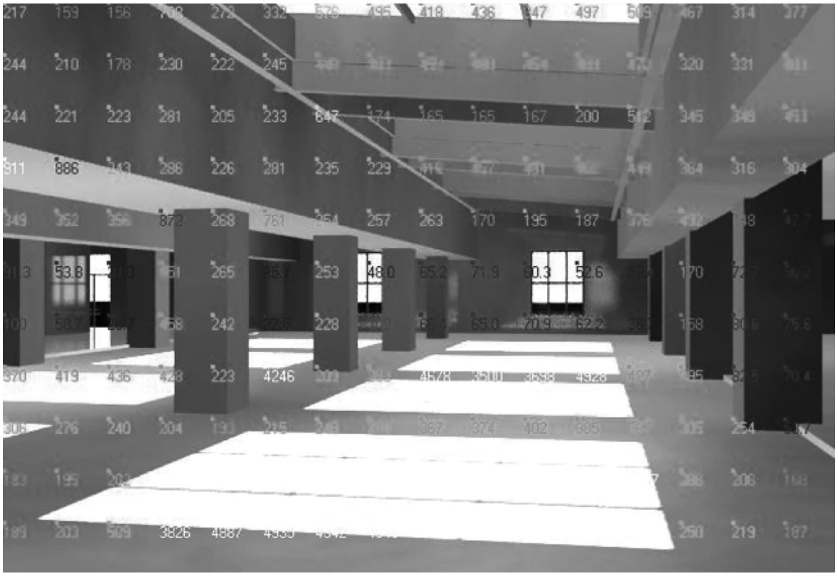


In some instances, models authored in one platform may not work directly with analysis platforms, such as the example in A and B. This caused the re-creation of the geometry directly in the analysis tool and also required time to coordinate and maintain the design and its iterations between the two models. The trend of these tools is moving toward better integration or additional analysis tools embedded inside the authoring applications. In application C, model geometry was directly imported into the analysis package, saving nearly 50 percent of the time needed to create and run the full analysis. Using this workflow, you can bring analysis to more projects, perform more iterations, or do the analysis in half the time.

The same workflow is true for daylighting (Figure 1.7) and other types of building performance analysis. By designing directly in the authoring tool, designers are able to move away from anecdotal or prescriptive design solutions and begin to rely on calculated results.

Building analysis can reach beyond just the design phase and into the whole building lifecycle. Once the building has been occupied, the use of BIM does not need to end. More advanced facilities management systems support tracking—and thereby trending—building use over time. By trending building use, you can begin to predict usage patterns and help anticipate future uses such as energy consumption or expansion. This strategy can help you become more proactive with maintenance and equipment replacement because you will be able to perceive how equipment performance begins to degrade over time. Trending will also aid you in providing a more comfortable environment for building occupants by understanding historic use patterns and allowing you to keep the building tuned for optimized energy performance. The application of this analysis comes in the Realize stage of BIM uses covered later in this chapter.

Figure 1.7
Daylighting overlay from Autodesk® 3ds Max®



Communicate

Using BIM to better visualize a building is a powerful way to communicate design intent. Creating documentation and visualization using BIM gives teams the added advantage of being able to communicate the design of the project in 3D, where it is more accessible to project participants. It is especially persuasive for those who are typically involved directly with the construction process but are still important decision-makers. Owners can benefit greatly from this type of communication. In this, visualization is an important tool for making design or construction decisions.

Although 3D visualization was initially conceived as one of the "low-hanging fruits" of a BIM workflow, this benefit has led to an explosion of additional perceptions of the design, including isometric details, renderings, animations, clash detection reports, and so on. This provides a much better way to communicate design opportunities and decisions between project stakeholders.

In the 1990s, if you wanted to create a rendering, a physical model, a daylighting model, an energy model, and an animation, you would have had to create five separate models and use five different pieces of software. There was no ability to reuse model geometry and data between model uses. One of the key uses of BIM is the opportunity to repurpose the model for a variety of visualizations. This not only allows you to not have to re-create geometry between uses but also ensures you're using the most current information in each visualization because it all comes from the same source. As the capacity of cloud rendering and analysis grows, the feedback will no longer need to process locally, and you'll be able to receive feedback faster.

This digital creation of the project has given us a variety of tools to communicate its aspects. Because the model is a single source of truth, it can be used in many different applications for communicating. Models may be imported into a gaming engine for an interactive virtual experience, allowing clients to virtually tour the building at their own pace, to help understand how this building will accommodate their functional and aesthetic needs. These same virtual models can also be physically printed through rapid prototyping methods such as 3D printing, creating small models (Figure 1.8) in a fraction of the time it would take to build one by hand. Many other forms of communicating through BIM are emerging as you read this book.

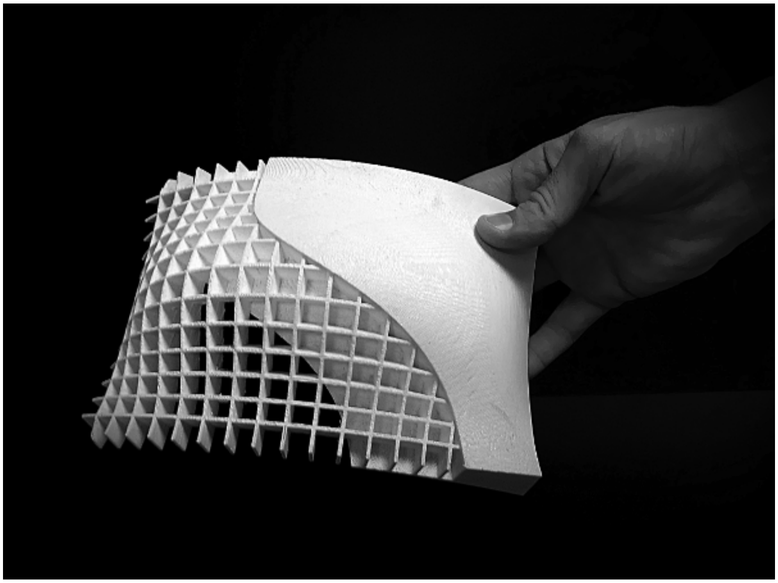


FIGURE 1.8
An example of rapid prototyping using BIM data
Source: HOK

If we consider a broad spectrum of representations, from tabular data to intelligently generated 2D documentation and 3D visualization, our traditional design deliverables become transformed. Schedules give you instantaneous reports on component quantities and space usage, whereas plans, sections, and elevations afford you the flexibility to customize their display using the information embedded in the modeled elements. For example, the plan in Figure 1.9 shows how color fills can be automatically applied to illustrate space usage by function. Because this is live in the model, changes can be made easily, providing confidence to the communicators and the receivers of this information that what they are seeing is accurate and can be the basis of valid decision-making.

Expanding 2D documentation to include 3D imagery also gives project teams the ability to clearly share the intent of more complex designs. It also has a positive effect on construction by reducing translation errors with illustrative documentation, rather than cryptic details and notations. Figure 1.10 shows a basic example of a drawing sheet composed of both 2D and 3D views generated directly from the project model.

Another obvious benefit to creating a complete model of the building is the ability to generate a wide variety of 3D images for presentation. These images are used not only to describe design intent but also to illustrate ideas about proportion, form, space, and functional relationships. The ease with which these kinds of views can be produced makes the rendered perspective more of a commodity. As shown in the left side of Figure 1.11, materiality may be removed to focus on the building form and element adjacencies. The same model is used again for a final photorealistic rendering, as shown in the right side of Figure 1.11. As the model contains information of both form and function, it's up to the communicator to decide what information is shared. A plan, perspective, and schedule can share common information. Because they come in different forms, the intent of the communication can be different. That is the great boon of having an intelligent model; you decide where and when information is communicated in any of the outputs with the confidence that it is the single source of truth.

Figure 1.9
Even 2D views can evolve to illustrate and analyze spatial properties.

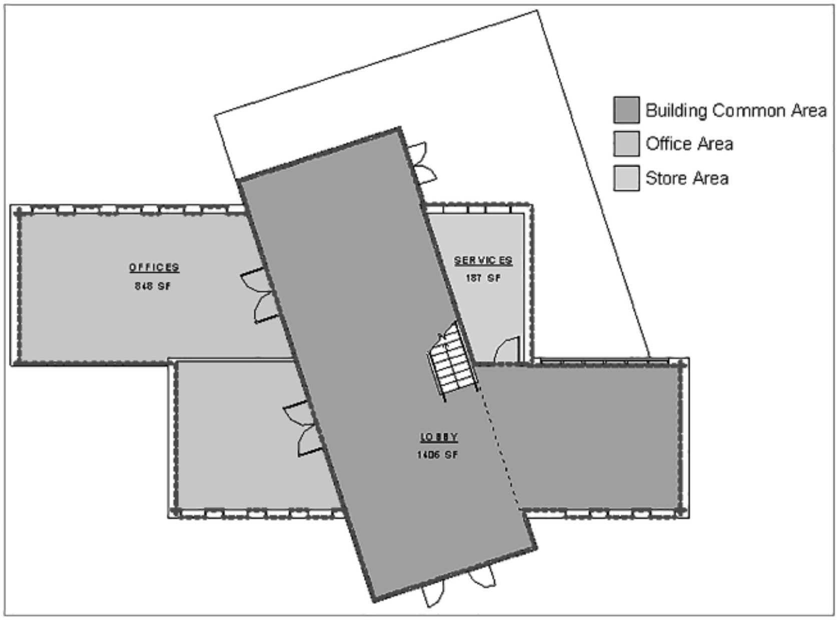


Figure 1.10
Construction documentation can begin to transform from 2D to 3D.
Source: HOK

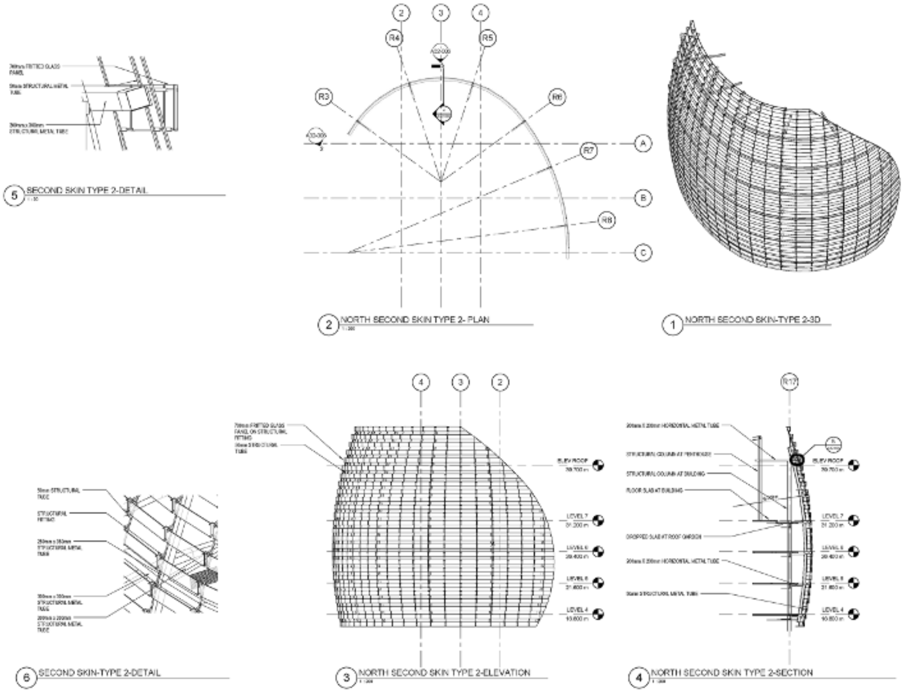


Figure 1.11
Two different methods of using 3D presentation views
Source: HOK

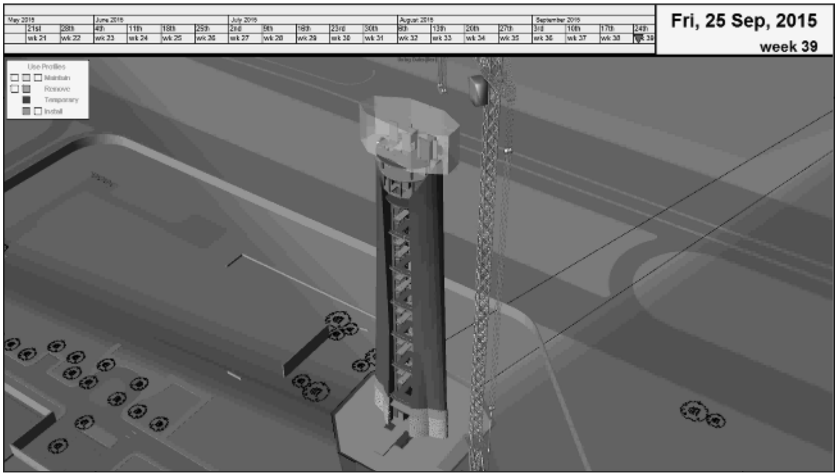
By adding materials to the BIM elements, you can begin to explore the space in color and light, creating photorealistic renderings of the building. These images can convey information about both the intent and context of the design. Iterations at this level are limited only by processing power and user intent. The photorealism allows for an almost lifelike exploration of color and light qualities within a built space even to the extent of allowing analytic brightness calculations to reveal the exact levels of light within a space, but with the added benefit of being derived directly from the working models. In this case, renderings can be an embedded process or a perpendicular instantaneous output. The first option would be rendering within the authoring tool. This would produce timely renderings based on the current models but may not be of the quality needed for presentation purposes. More high-end renderings used for marketing would normally require exports from models brought into specific rendering tools. These renderings can be more stylized or photorealistic; however, they are a snapshot in time of the working model and take additional preparation to be useful. This in effect ends their BIM connectivity.

The next logical step is taking these elements and adding the element of time. In Figure 1.12, you can see a still image taken from a phasing animation (commonly referred to as a 4D simulation) of a project. Not only do these simulations convey time and movement through space, but they also have the ability to demonstrate how the building will react or perform under real lighting and atmospheric conditions. All of this fosters a more complete understanding of the constructability and performance of a project before it is realized. This is also a common method when trying to understand construction sequencing by contractors as they are planning the building of the facility.

Realize

The use of BIM can potentially remove the direct human input to develop specific elements of the facility. Using the data generated through BIM-based planning and design processes to fabricate or manage building elements of the facility allows facility owners to realize some of the most beneficial aspects of the entire endeavor. Using BIM for facility management can enable owners to take advantage of the facility data throughout the building's lifecycle to support safe, effective, and efficient environments. The maintenance of this data can improve efficiencies through having accurate as-builts. It can promote the optimization of operation and maintenance of the facility's systems to reduce energy usage. Let's explore two main concepts of BIM realization: assemblage and control.

Figure 1.12
A still from an animation showing accurate physical conditions for the project
Source: HOK



Assemblage By developing building information modeling, you can replan building elements way before they are actually fabricated and assembled. This can include the specific specification of existing systems or the design of custom systems to be installed in the facility. Examples include picking a water pump that fits both the functional requirements and the spatial requirements of a mechanical space or the opportunity to prefabricate a custom receptionist desk for a highly designed lobby space. During the projects' early phases, these processes can be used to generate multiple design schemes. For construction, these processes can help the contractors to understand the process of bringing materials on-site and how and when they should go together. It might also inform them how to pre-assemble custom systems for delivery to the project site, preventing cumbersome storage or barriers to successful assemblage such as poor weather or misinterpreted documents. Being able to assemble systems with the aid of machines, such as CNC (Computer Numerical Control) systems, can reduce not only costs but also the time needed to install components in the facility. Examples of prefabrication might include wall systems, ductwork, and curtainwall.

Control Building information modeling also allows operators of the facilities to help manage and maintain the equipment and systems once they are installed on-site. If a database was created during the planning, design, and construction phases of the project to ensure that all as-built systems are well documented with specific properties associated with each system, operations and maintenance stakeholders not only will have a better knowledge of what systems they have but also may have some automated processes that could schedule maintenance requests or connect in with building system analysis tools. When you do an analysis of the lifespan of a building, you will see most of the time is in the occupancy stage. This really means that most of the money spent on the facility is running it. If BIM can help reduce the costs of operating and maintaining a facility, this becomes a huge benefit to owners that can be realized through a building information modeling process. Architects are the primary origin of this information that can help owners achieve these benefits. A good model-based database can help an owner solve maintenance issues more quickly, may be able to find potential issues more readily, and can be able to plan future construction much more easily. The use of this data to regulate facility systems potentially allows facility operators to optimize their operations. It is even possible that in the future, building systems could be automated because of information generated by BIM. Being able to plan the system integrations ahead of time allows for more intelligence built into the facility. An example of this is when a thermostat is programmed to modify the settings of the HVAC system in response to preprogrammed rules by its connection to an intelligent monitoring system, enabled by the BIM. Benefits such as these can really help owners optimize the operations and maintenance of the facilities and demand more services from its designers, such as yourself.

Integrating Tools Inside a BIM Workflow

As you have read with the explanations of people and processes involved with BIM, the last aspect to discuss is the technology. Without the technology you would not be here; it supports all the other things that make building information modeling possible. The thing you may not realize is that even though it is the foundation of all these other great opportunities and benefits, it is still a lesser aspect of the entire BIM ecosystem. This may confuse some readers, but in our experience we find that the most meaningful changes happen with the people deploying these processes and the methodology they take in transforming their work. The tools that people use in their workflows to generate geometry and data change only slightly from year to year. Technology is constantly being improved, made more efficient, and better integrated with other tools in the market. You as an individual user have little influence over this. Understanding the existing capabilities of tools is important; however, change in the technology sense is much more limited than improvements to your process and skill sets.

The purpose of this book is to connect your knowledge as a person with the best understanding of authoring tool's capabilities. That specific authoring tool, of course, is Autodesk Revit. Coming to this realization, the user must understand that an expert of the software is not an expert in BIM. Many people know the functions of the tool based on learning or experience but still do not have a grasp on why they should do something and when they should do it. That comes with having a better understanding of not only why BIM is beneficial but also how all these things come together to create an architectural zeitgeist. Throughout this volume we hope to make contributions to your understanding of all three and to help you make the connection between opportunities in the application and a methodology to deploy them, with the overall sense of what it means to your project and to your organization.

What Is Revit?

Autodesk Revit software is a BIM application for authoring parametric 3D models that generate geometry with embedded information for the design and construction of buildings and infrastructure. It is from these intelligent models that plans, sections, elevations, perspectives, details, and schedules—all of the necessary instruments to document the design of a building—can be derived. Drawings created using Revit are not a collection of 2D lines and shapes that are interpreted to represent a building but live views extracted from virtual building models. These models are a compilation of intelligent components that contain not only geometric attributes but also data informing decisions about the building at every stage of the process, including occupancy.

Elements in Revit are managed and manipulated through a series of parameters that we will discuss in greater detail throughout this book. These elements have bidirectional associativity, allowing the user to change the 2D views to change the 3D model or to change the 3D model to change the 2D views. If you move a door in a plan, that door is moved in all of the elevations, sections, perspectives, and so on, in which that object appears. In addition, all of the element's properties contain information internally, which means that intelligent annotations are directly linked to the objects. These tags display the object's data directly, rather than a manual entry interpreted by the user. When contrasted with traditional CAD tools that store element information only in the annotation, Revit gives you the opportunity to more easily input, manage, and export your project data for project coordination and execution.

The Bottom Line

Focus your investment in BIM. Since using Revit software is a change in workflow, it is also important to understand the change in staffing and who is needed to perform what roles on a project.

Master It What are the three primary roles in a Revit project, and what are the responsibilities of those roles?

Understand a BIM workflow. Understand how projects are completed in BIM and how the use of Revit software on a project can change how information within a project is created.

Master It Explain one of the primary differences between a more traditional 2D CAD-based workflow and producing documents using Revit.

Leverage BIM processes. Understanding the level of risk your firm is willing to take in new technologies will help you establish goals for your future use of BIM.

Master It Using the three areas of firm integration (visualization, analysis, and strategy), define how those areas overlap for your firm or project.