

## Managing a BIM Model

Consider this analogy. A construction manager must understand the technology of construction. But the more crucial job is orchestrating the work of hundreds of organizations—coordinating the assembly of materials on-site with decision-making, sequencing and supply chain management. Managing the interrelationships is at least as important as understanding the technology of the work. In the simplest sense, it doesn't do any good for a construction superintendent to know about forming and finishing concrete if the concrete truck isn't scheduled for delivery at the right time.

A BIM model has similar requirements. Managing the development of the virtual construction model requires skills that are similar to managing the real thing. Too often, BIM production is staffed with people who understand computer technology but don't understand how to manage the workflow into a BIM model from multiple sources.

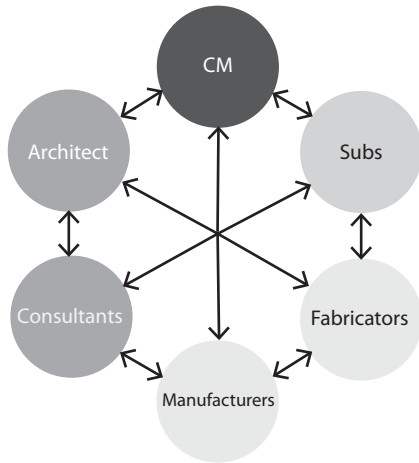
The management job requires setting BIM standards, understanding constructibility and construction sequence, evaluating supply chain data and vetting information that is submitted for input into the model. But most of all, it requires understanding how and when to suck this information from multiple sources into an integrated model. The manager must have clout in the organization to get the attention of the extended team to schedule information flow, analysis and problem solving. And since inputs to a BIM model may ricochet through the model, the manager must review and evaluate the accuracy of inputs—just as a CFO ensures that there are procedures to evaluate the inputs of financial information before they are posted to a general ledger.

With the technology available at this writing, BIM models may become so large that they need to be broken up into sub-models to keep them manageable and running smoothly or updates and clash detection become time consuming.

A project that intends to exploit the benefits of BIM needs a manager and an interdisciplinary team staffed with people from the organizations that contribute to the model. The team can integrate drawings from the AEs, subcontractors and manufacturers into a confederated model, develop 4D and 5D models and detect coordination problems with clash detection routines. Constructibility reviews trigger design adjustments.

*Managing the assembly of a BIM model is analogous to managing the assembly of a building—and needs the same managerial skill.*

*A BIM manager must have procedures to vet the accuracy of inputs—just as a CFO ensures that there are procedures to evaluate the inputs of financial information before they are posted to a general ledger.*



*An integrated BIM has many contributors and requires a manager who knows how to lead people and understands construction sequencing as well as a construction superintendent. BIM model management also requires support of the owner and the management team.*

RFIs are anticipated and should be minimal. In developing the model, questions surface before construction.

A BIM model manager requires the support of the owner and the management team, who must set policies to adopt the technology, buy and install the software for members who do not have it, train the team, and champion its use. Finally, they will need to develop policies to support workflows for a BIM process that may be developed by the BIM model manager. The manager will develop and publish a BIM manual that clarifies protocols, workflow and responsibilities for the firms that contribute to the model.

The BIM model manager must be a person with good interpersonal skills to build the collaborative culture required to produce an integrated BIM model. The manager must build trust and networks of personal communication within the contracting team. As with real construction, the more personal contact and the more trust, the more collaboration.

BIM allows trust to be built early, well before construction begins. There's an opportunity to allocate model space to each subcontractor to give each of them confidence that the process will not only find clashes in their systems before they get to the field, but that the subcontractor will have the ability to model the clearances and working space needed to install their work.



Architects and engineers have typically been the primary source of BIM models, fulfilling their traditional role in developing the drawings and specifications that document the *product*—the description of the design, the intended physical result.

CMs have usually taken the lead in providing Project Management Information Systems (PMIS)—gathering and integrating data from the extended project team. These systems have concentrated on *process*—tracking contractual matters such as cost, schedule, RFIs and change orders.

But now CMs are developing in-house BIM teams and developing BIM models before construction.<sup>47</sup> BIM is not the exclusive territory of the AE—nor should it be.

*Ultimately, the core team will likely build integrated groups to produce integrated documents.*

Enlightened owners are facilitating integrated groups to produce integrated documents. Clearly, managing virtual construction will require technical knowledge of both *process* and *product*. Virtual construction will require AEs with product expertise and CMs with process expertise. It will require effective collaboration; owners will provide the platform.

## Dynamic, Living and Incomplete Model

An idyllic vision of BIM is that of a fully integrated and complete BIM model—a virtual representation of the building, available for study before construction begins with product data that informs the owner’s facility management organization after construction. It would include construction details, specifications, cost, schedule, systems, construction sequences, off-site fabrication schedules and shop drawings. It would contain 4D schedule data and 5D cost data and be enabled with CAD-CAM instructions for driving machine tools in off-site shops. It would include product information, replacement part data, maintenance information and warranties. Wow!

*For the foreseeable future, no BIM model will ever be complete.*

Then, to continue the idyllic vision, the extended project team (AEs, CMs, subcontractors, manufacturers and fabricators) could pour over the model and find construction problems in electronic space before entering the costly physical space of the real world. They would get the change orders and RFIs out of the way before construction begins and they would validate the workflow and supply chains.

It’s not an entirely foolish pipe dream. Many owners have continuous building programs. They may have prototype designs or at least projects with many similarities. They may have BIM models of building modules that can be assembled in various ways for variations in their project needs. They may have in-house staff or continuous relationships with AEs, CMs, subcontractors and suppliers. After each project, they can develop continuous improvement for feedback into a prototype

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<sup>47</sup> AGC has published *A Contractor’s Guide to Building Information Modeling, Edition One*, that guides contractors in the use of BIM.

BIM model to further refine its value. It's conceivable that these owners could approach that vision.

However, consider the realities of a more typical project. AEs avoid including final details in the Contract Documents so they can maintain competition among multiple manufacturers. Subcontractors, manufacturers and fabricators don't detail their systems until they are under contract. Final construction details aren't available until after products and systems are purchased. And if a project uses fast-track scheduling, complete coordination can't be done in electronic space before construction begins because the design is incomplete.

Furthermore, many subcontractors and suppliers are not BIM literate. Those who are BIM literate may use incompatible software. Even with compatible software there is huge variability in the quality of the model they can produce. So the BIM model will be incomplete, augmenting the electronic database with legacy CAD or paper products.

Design Assist will provide some opportunity for subcontractors to have input during the initial design phases. That will help AEs develop the model for specific products—and more important, allow subcontractors to guide the design toward shop-fabricated methods.

*Owners may not have the people, the technology or the motivation to maintain BIM models after a project is complete.*

Not all owners will have the in-house resources to maintain the models or keep them up to date. And for those that do, the amount of information put into the model, and the cost of doing it need to be tempered with the capability of the owner's facility staff and the anticipated future utility of the model.

There is also the cultural shift to deal with. Owners, AEs, CMs, subcontractors and manufacturers will have different levels of IT skills and different inclinations to use electronic data management.

Furthermore, most owners have existing facilities and existing means to record data about their use. These legacy systems may include facility management software that does not integrate with BIM or, as is the case with most owners, paper in filing cabinets. They will be reluctant to spend the money to bring all their facility data to a new platform.

**Always limited:** For the foreseeable future, a BIM model will fall short of the vision. The skill sets, hardware constraints and staffing limitations of designers, builders and owners will—as in

all technology implementations—not fully exploit the potential. And as the capabilities of these organizations increase, so will the capabilities of the technology. It will always be like catching a moving train.

And so, recognizing that a project might last multiple years and that both the organization and technology will change, a wise team will consider a BIM model to be a living, dynamic thing, accepting additions and changes throughout the life of the project—continuing to grow during the project—and for BIM-literate owners after occupancy.

The vision of a complete model for virtual construction is possible, and although all the capabilities mentioned above are within our technological reach, only some are implemented on any project. A BIM model manager must decide, given the sophistication of the project team, how far to go.

## Barriers to BIM

The ultimate objective is to build an integrated BIM model—a virtual building—before we make expensive mistakes with concrete, glass and steel. But tradition, contractual separation, archaic laws, technical limitations, interoperability problems and culture hinder us.

**Software and hardware constraints:** A BIM model theoretically has unlimited ability to hold information. But any practical project model will fall short of what is theoretically possible. Despite faster and faster computers and more efficient software, the model slows down as it enlarges. Consequently, models for large buildings are typically divided into submodels that can be updated faster. Special software is usually needed to integrate the different parts of the model and run the clash detection routines.

**Cost practicalities:** At some point, it becomes impractical to add detail to the model. We still assume the builder will use some judgment in the field. A drawing doesn't need to show all the nail locations in a wood frame.

**Legal concerns and universal acceptance:** The fruition of BIM will depend on widespread use by designers, contractors and manufacturers. But as long as legal concerns make integration tentative, and until trade contractors and

manufacturers are operational with BIM, we will limp along with incomplete integration.

**Trust in other models:** An architect or a CM who accepts contributions from others will inevitably accept material that may be difficult to evaluate. Even though contributions to a federated model may be tracked and responsibility recorded, there will be concern for the integrity of the whole.

**Interoperability:** Any CM or PM who has managed a program that included multiple architects and multiple CMs has faced the frustrating problems of interoperability in trying to integrate data from different Project Management Information Systems. It is hard to share data between Autodesk's Constructware, e-Builder and Meridian's Prolog. The same problem exists with BIM software.

A fully integrated BIM model is a vision, not a reality. At current levels of development, architects, engineers, consultants, builders and fabricators may have independent BIM models, legacy CAD systems and legacy paper systems. Those who use BIM software may not use the same programs and require third-party software to integrate the different work products.<sup>48</sup>

**Document signing:** The largest part of an architect or engineer's fee is compensation for producing Construction Documents. Then 40-60 percent of the Construction Drawings are discarded and replaced with shop drawings—about 1-3 percent of the project cost is wasted.

Integrating shop drawings in a BIM model eliminates this time-consuming and costly redundancy. It also solves problems. If fabricated products don't fit in the 3D space properly, the problem is likely to surface and get fixed.

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<sup>48</sup> The International Alliance for Interoperability (IAI) ([www.iai-international.org](http://www.iai-international.org)) functions as a council of the National Institute of Building Sciences (NIBS) to improve interoperability. NIBS is defining BIM standards. The Facility Information Council (FIC), an NIBS Council (<http://www.facilityinformationcouncil.org/>), "provides support for the development, standardization, and integration of computer technologies and software to ensure the improved performance of the entire life cycle of facilities from design, engineering and construction through operation, maintenance and retirement phases."

However, most state laws stipulate that architects and engineers must only sign drawings done under their supervision. So AEs are properly reluctant to sign documents that include drawings prepared by others.

*Most state laws require AEs to supervise drawings they sign. That means that they can't sign drawings printed from "federated models" that include work done by other parties.*

The typical solution for this annoying problem is for a team to simply create a subset of the BIM model that has been produced under the AEs supervision for the designers to sign. Then the team calls the integrated BIM model a constructibility set, shop drawings for the building, a quality control document or whatever.

But as long as the model is not an actual deliverable, signed like a sheet of drawings, the applicability will be suspect and the true potential will be limited.

Although BIM software is useful in documenting the work of a single company, its greater value is integrating the work of multiple companies—sharing designs, specifications and information among the extended project team. But sharing blurs authorship and blurred authorship blurs responsibility for the design.

The process of assembling companies necessary to design and build a structure has assumed separate contracts, responsibilities, scopes, liabilities—and separate but clearly allocated and defined risk and responsibility. Statutes, case law and insurance products reflect these contractual silos.

The traditional assumption is that the AEs are responsible for the drawings and specifications. If shop drawings are integrated in BIM, the AEs are concerned that they will assume responsibility for their accuracy and the performance of the product. So in project delivery processes with separate contracts, the AE is circumspect about integrating shop drawings. Practitioners and their attorneys partition responsibility by partitioning drawings—balking the development of integrated drawings and crippling the benefit of BIM.

One approach has been to add shop drawing to the BIM model clearly identified in the model as the sub's work. The subcontractor would retain responsibility. However, if the AE and the subcontractor collaborate (a desirable activity), the responsibility becomes unclear.

Until the licensing laws and the insurance industry catch up with technology and practice, it will be necessary for the AE team

members to print a report from the BIM model that depicts design work that they can comfortably claim has been produced under their supervision. Then they can sign the drawings, obtain required permits, and the team can move ahead and integrate drawings as extensively as possible. The BIM model can be characterized as a “Quality Control” or a “Virtual Construction” document.

## Who Pays for BIM and Who Benefits?

A BIM model improves the design, improves coordination, reveals construction problems and helps the team optimize both product and process. Savings in time, money and grief pay for its cost.

*Traditionally the Construction Documents are done by the AE. More and more, sophisticated CMs with in-house “virtual construction groups” are producing federated models that are built on the AE’s drawings but include shop drawings. Many firms consider the product to be a “shop drawing for the building.”*

However, in traditional processes the cost of a BIM model is borne by the AE, but the savings benefit multiple sources—the AEs, CMs, subcontractors, suppliers, manufacturers and, of course, the owner. The cost of building an integrated model surpasses the usual cost of producing typical Construction Documents and so, in projects where AEs are paid a traditional fee, the AE objects to the idea of assuming the total responsibility of managing and developing an integrated model. However, in a Design-build, Bridging or IPD project the management committee can agree to fund and staff the required effort and the extended team can contribute resources. Since the benefit is to the project, it can be paid for by the project—not by a single project participant.

## Legal Conundrums

**Intellectual property:** Traditionally, architects have attempted to retain ownership of the Construction Documents. With larger and more complex projects there may be multiple architects and engineers in different locations across the globe, further complicating ownership. Meanwhile, CMs and subcontractors are contributing to the models. And owners, particularly serial builders, have challenged the ownership by architects with increasing frequency. They argue that if they pay to have the model made, they should own it.

In a traditional process with separate contracts, these issues may cloud the ownership. But with design-build, Bridging or IPD it is likely that the members of the team will argue that since the BIM

model is a collaborative work, it belongs to the members. It can be argued that all of the collaborators have an interest represented by their contribution. They can share it among themselves in parts or as a whole—however they agree.

But since the BIM will morph into a useful tool for the facility managers, owners will also want ownership and they will likely insist on it. (However, it is likely that the team will want a contractual restriction on the owner’s ability to use the model for future construction—or permission with indemnity of the team.)

Digital information in a BIM model can be easily copied and reused. Subcontractors, their manufacturers and suppliers may provide proprietary designs to the BIM model and may require agreements that prevent fabrication or reuse of the design by others. Confidential processes may be used that must be protected. Access and use of the model must be defined—either in the contracts that form the legal relationship of the team or as BIM management procedures.

## The AGC BIM Addendum

The AGC has issued a BIM Addendum to its ConsensusDOCS 301. It is a thorough document, written clearly by construction professionals and lawyers who understand BIM and have thoughtful approaches. It’s educational and informative. The concepts should be understood by any construction professional involved in a BIM initiative.

The Addendum is designed for traditional processes such as design-bid-build or negotiated GMPs and avoids rupturing traditional legal relationships among the owner, architects, engineers, GCs, subcontractors, suppliers and manufacturers. It is designed to be attached to any project contract including subconsultant and subcontractor contracts.

It defines a model as a “Contribution” from one of the project participants.

- There are multiple models for analysis, preliminary design studies or renderings.
- A *Full Design Model* includes architectural, structural, MEP and other design phase models and is analogous to traditional Construction Documents.

- A *Construction Model* includes shop-drawings and related information. It might include information imported from a Design Model or from traditional Construction Documents.
- A *Federated Model* is an assembly of models. The models must maintain their authorship and remain separate. The models can't be interactive: one model must not be affected by a change in another model. They can be linked so they can be used for approvals, coordination, quality control, clash detection, estimating or, ultimately, facility management. However, no one can change another's model, so clear responsibility may be maintained.

To maintain authorship identify and responsibility, the Addendum assigns tasks and responsibilities to *The Information Manager* who must control access to the model and record each input, deletion or change with the author's contact information, date, time, etc., and maintain an audit trail of such modifications.

The BIM Addendum also:

- States that if there is a software malfunction, the owner bears most of the risk and that a party to the BIM Addendum may be entitled to a time extension.
- Requires that each party agree to waive claims against the other parties to the agreement for consequential damages.
- Requires model users to quickly report errors or omissions they discover in order to minimize claims and liability.
- Provides rights to the owner to use the model according to the agreement between the owner and the design professionals.

Each party to the BIM Addendum warrants to the other parties that it has rights to the copyright of its Contributions and agrees to indemnify and hold other parties harmless in the event third parties claim copyright infringement. And each grants the other parties a limited, non-exclusive license to use that party's Contributions.



The melancholy aspect of the AGC Addendum is that, despite the wisdom of the authors, it is predicated on using powerful integration software for a partially integrated process. Keeping design and construction models separate is inefficient and neglects useful collaboration, construction feedback to designers,

quality control and value engineering initiatives. The need to maintain model separation precludes interactive relationships and thereby gives up some of the potential power of BIM. The contractual separation of the key team members creates much legal boilerplate and procedural documentation. But that's not the fault of the AGC or the authors of the Addendum. It's our industry's burden of tradition and the legal and insurance structure that surrounds our practice.

The BIM Addendum falls short of envisioning an integrated, seamless design and construction process that allows us to build virtually before we pour concrete. But it wasn't intended to do so. And we know that vision is at the top of a long hill that must be climbed. It will be wonderful when we can watch the technical understanding and intellectual energy that went into the AGC BIM Addendum applied to that vision—unfettered by our industry's creaky traditional processes.

## What's the Design? Who's the Designer?

The very concept of integrating information from a collaborative project team distributes the creation of a design across a number of organizations.

- Most owners are serial builders. They create standards and prototypes that they give to AEs and CMs to implement.
- CMs participate in the development of design concepts and affect the design with their recommendations for materials and systems. Constructibility and value engineering studies often have substantial effect on the design.
- Manufacturers and specialty subcontractors produce shop drawings that implement but often modify the design intent.
- Manufacturers and software vendors provide 3D or BIM “content” that describes their products over the Internet for insertion into Construction Documents.
- Design Assist strategies involve trade contractors in the design process.

**The design:** A singular advantage of digital files is that they are easy to modify and update. So BIM models tend to be living documents—growing through the evolution of the project as the design develops, as clash detection uncovers problems, as field conditions develop, as changes are made and final configurations are adjusted during construction.

And yet designers need to know what they have designed and are responsible for; owners need to know what they approve; contractors need to know what they agree to build; approval agencies need to know what they have approved; and inspectors need to know what to accept. The moving train of a BIM model is a problem when there is a static document required for an agreement with a contractor or approval from an owner or permission from an entitlement agency. Consequently, a BIM model must produce reports that define and freeze these categories of documentation.

*In 1857, Otis installed an elevator in a building, something that the manufacturer knew more about than the architect.*

**The designer:** A century ago it was an exception to have industrialized products in a building. When the professions of architecture and engineering emerged, AEs designed building systems: heating, enclosure, partitioning, roofing and millwork systems. Today, most of a building is manufactured off-site from designs produced by manufacturers. Increasingly, AEs design buildings that include technology that the AEs do not understand as thoroughly as the manufacturer. The AE's job has changed. It is to evaluate and integrate systems and products designed by others.

Recently, the AIA distributed an online survey to measure the desire for BIM content provided by manufacturers. The AIA asked for interest in partitions, doors, windows, floor coverings, ceiling systems, kitchen equipment, elevators, furniture, electronics, casework, furniture systems and equipment of all kinds for single-family residential, healthcare, commercial/retail, multi-unit residential and hospitality, Lab/Hi-tech/Research, K-12 and "other" kinds of projects. This plentiful and commonly used BIM content, available from the manufacturers, contains algorithms and other properties developed by the manufacturers that may adjust the object to a design as it is installed. However, electronic content created by manufacturers can be over-detailed—leading to an oversized model that slows further development.

Software companies are working on BIM software that will adjust related building systems to design changes. For instance, if window areas are increased (increasing heat loss and gain) the ducts will automatically be resized. If floor plans change the software will check code compliance. If a room is enlarged the beams will get bigger. But the current state of the art is bumpy. These things don't change with the click of a mouse and they still need checking and oversight by architects and engineers.

“Smart systems” and “smart objects” may not be created by licensed architects and engineers. However, AEs will use increasingly sophisticated software tools and embedded objects downloaded from manufacturers. The design may be distributed to different computer systems and used by different participants.

Conceivably, there can be a dispute over the cause of a malfunction in an elevator system. (For instance, did the rails move because the structure deflected or were they improperly aligned during installation?) As industrialization and information technology continue to make more sophisticated systems available to architects and engineers, and present them to the industry over the Internet as smart self-adjusting objects, the problem of tracking responsibility for design components will become more difficult.

Most software contains licensing agreements that protect the software author from liability in its use. While AEs and CMs may place responsibility on manufacturers for the performance of their physical products, they will be unlikely to deflect responsibility for errors produced with the software they use—any more than a taxpayer could blame a publisher of tax computation software for underpaying income tax.

The responsibility for the elevator problem is far easier to track than a system problem that was designed with smart content downloaded from a manufacturer, adjusted by a CAD operator, modified by owner standards, value engineered by a CM and interpreted in shop drawings by a subcontractor.



Architects and engineers have traditionally been responsible for the design. At a high level of conceptualization, that will remain true. But more often, owners who are serial builders will influence not only design requirements, but design solutions. As the intellectual capital of CMs, trade contractors, manufacturers, suppliers and consultants is added to the design, the responsibility will be more murky and will likely fall on the owners to shoulder more and more responsibility.