



The Building Information Model:

A Look at Graphisoft's Virtual Building Concept

A Cyon Research White Paper
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Executive Summary

The spread of computer use has brought a new way of thinking to many business and engineering processes. Many benefits of error reduction and process time compression are available through the *building information model*—an approach to documentation that dictates that all project data be stored in one and only one location. This concept is the result of a fresh look at the construction process, taking into account modern computational tools.

Graphisoft's Virtual Building is an amplification of the building information model with an object-based three-dimensional parametric database. There is no doubt of its value to the construction process as a whole, or to an owner. The major challenge it faces is that in many projects, the owner is not in direct control—and thus finding a 'customer' for the Virtual Building may not be simple.

Construction Today

Traditionally, construction projects are defined by numerous documents, among which there may be overlap and inconsistency. These are maintained separately by different project participants, and inconsistencies are typically discovered only in the field—when tradespeople working with different documents bump into each other.

For example, consider the positioning of a column in a multi-story building: Modifying a layout of the ground floor to move the column generates no other changes automatically; layouts of other floors must be changed by hand, as well as, say, mechanical and electrical plans based on those layouts.

Dimensional consistency is also not assured. That is, the numbers in the dimensions on drawings may not be accurately reflected in the geometry; drawings are often treated as unscaled relational schematics.

Lack of consistency among drawings in a set and lack of internal consistency often lead to expensive construction errors.

The Building Information Model

The idea behind a building information model is that of a single repository. Every item is described only once. Both graphical documents—drawings—and non-graphical documents—specifications, schedules, and other data—are included. Changes are made to each item in only one place.

Thus, every user of the repository can be certain that what they are seeing is exactly the same information that every other project participant sees. This one change to the way project documentation is handled can greatly reduce the number of communication problems that slow down projects and increase costs.

However, a building information model does not necessarily ensure bi-directional connectivity among all manifestations of the model. In some building-information-model systems, information is extracted, rather than linked; production drawings, for example. Modifications made to these extracted documents are not reflected in the model; it must be separately updated.

The building information model also raises, but does not directly address, additional questions: Who owns the data in the model? Who is responsible for updating it? What about access and security?

Enhancing the Building Information Model

Having all the documentation in one place creates an opportunity to apply additional technologies to the building process—in particular, three-dimensional modeling, based

on objects; full document linking, for comprehensive model integrity; and logically centralized control of project information.

Striking visual presentations have been used by architects for many years. Computers have made it possible to create realistic renderings with astonishing control over lighting, color, texture, and even animation. The use of data-based three-dimensional models adds an additional factor: full verisimilitude, faithfulness to reality. Not just a great picture—a complete representation of the project, including materials, finishes, behavioral attributes, and more. A complete three-dimensional representation of the geometry of the project is its foundation. But it is much more than that.

Graphisoft's implementation of the building information model—the Virtual Building—is a database that contains *objects*—things that are of interest in the design and construction process. For example, a door is an object; a window is another; a truss is another.

In the Virtual Building, a door is not simply a collection of points, lines, and curves arranged to look like a door—it is an *object*, with an object-oriented infrastructure, that displays many of the qualities and behaviors of a real door within the context of the building information model.

When a door is inserted into a wall, the wall parts and “heals” to accommodate it. Moreover, the wall will only allow the door to be inserted into it in “reasonable” locations.

The underlying data of the Virtual Building contains “intelligence.” For example, it ensures that, although a door has an independent existence, it will move with a wall in which it has been inserted.

Moreover, the Virtual Building can have *parametric integrity*. Geometry can be changed by modifying dimensions and other constraints. All of its objects “know” about the other objects, and can adjust to changes, within specified limitations.

Also included in the “intelligence” are many non-geometric attributes—fire-resistance, for example, or manufacturer's name and model number.

This “intelligence” makes for a realistic model, one whose every aspect is linked to every other aspect to reflect reality. A change made to any “view” of the model, whether graphical or textual, is immediately reflected in every other “view.”

Of course, quantity surveys, bills of materials, window and door schedules, finish schedules, and cost estimates can be prepared almost entirely automatically from the Virtual Building. It offers a level of management control that is unheard-of in conventional construction processes.

Why a Virtual Building

The main benefits of the building information model derive from having a single consistent database to represent the building throughout its lifecycle, from design through construction, operation, and ultimate disposition.

The value of these benefits is enormous. In a traditional project, each phase has its own model.

These models cannot be kept consistent. The resultant miscommunications are expensive and time-consuming.

In the building information model, all phases are based on one model.

Consequently, all documents, schedules, and communications about the project are consistent with each other.

Graphisoft's Virtual Building's additional features present users with the following benefits:

- Simulation
- Collaboration
- Auditability
- Maintainability

Simulation. Design is an iterative process of ideation, drawing, discovery, and modification.

Most of the problems that a design solves are worked out in the design process. Some, however, only manifest during construction, when they are far more expensive to fix. We strive to uncover as many problems as possible during design, and fix them before digging, pouring concrete, or fabricating steel.

A drawing is an abstract model of the building. The more detailed we make it, the greater insight it gives us into the problems we must solve to complete the building. Since design is a process of trial and error, we want to make as many trials as possible—and to make them while they are inexpensive.

The Virtual Building is a detailed simulation of the building. Its verisimilitude allows us to try out many approaches, without having to construct physical models; the model behaves almost exactly the way the real building will, so problems can be fixed before they turn up in the construction process.

Verisimilitude is a powerful quality. Analyses—such as structural, thermal, solar, and so on—will yield high-quality results because of it. It can even be used for “4D” progressive construction simulations, for example, to support decision-making.

In fact, the dynamic nature of the model makes it possible to maintain its faithfulness to reality throughout the construction process, and on into operation and even repurposing. No more “as-built” drawings! Since the model continues to be updated during construction, it always faithfully reflects the actual building.

Collaboration. Most construction projects involve a large number of participants—owner representatives, consultants, builders, tradespeople, and more. Traditionally, each is issued sets of documents—which must be tracked and coordinated. Changes made by each must be assimilated back into the master set of documents.

All of this takes time, and involves many steps; the process is fraught with the potential for error.

The Virtual Building, as a building information model, is accessible to all the project participants. All changes are immediately reflected in it. It becomes the central touchstone of the collaborative process, reducing the opportunity for communication errors—which are the greatest source of error in project execution.

Auditability. The building information model constitutes a kind of “project memory”—a place where everything that happens on the project can be stored. All changes to the building information model are recorded; it is always possible to ascertain who made a change, and when. Strong accountability throughout the construction process is thus assured.

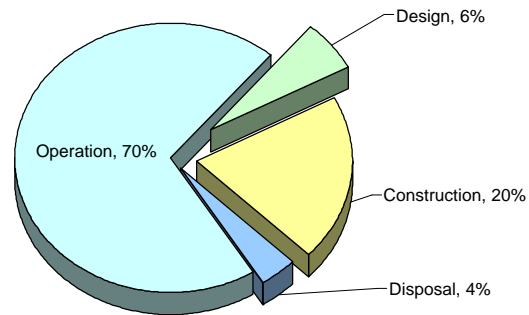
By implementing appropriate procedures, the building information model can thus embody an audit trail for the project—an authoritative record of everything that happened, indexed by time.

Maintainability. The Virtual Building serves as the basis for design, planning, construction, project management, and facility management, providing a vehicle for moving seamlessly from one phase of a project to the next. And since more than 70% of the total lifecycle cost of a building is incurred after it is handed over to the owner, it is particularly valuable in the period following construction.

Why is it better?

Architecture and construction have evolved over a period of centuries. There are many parties and processes involved in the planning and construction of a building. Their details and coordination are complex, more a function of history than of a modern planning process.

The traditional process leading to the construction of a building is fragmented. And the larger the project, the more fragmented it is.



Consider documentation. To find information about any particular aspect of the construction project, you have to go to multiple documents—which will rarely agree with one another. A tradesman might have one set of plans, while the architect may be using a different set, at a different revision level.

In the building information model, this can't happen. All drawings, all views, are produced on an as-needed basis from a single source—in the Virtual Building, it is an intelligent three-dimensional model that is the heart of the system. All project participants have access to the same information, at the same level of updating.

Moreover, knowledge about the building grows as the project progresses—and it is all consistent. The model becomes a better and better representation of the building itself over time.

At the same time, any type of current construction documentation can be produced from it on demand, on the screen or in hard-copy form.

Who benefits?

Architects benefit from the Virtual Building by having an environment in which concepts can be quickly explored and evaluated—and presented, as well. It is also an excellent framework for resource leveling and improved project control.

Engineering consultants have a reliable source of information for their analyses and reports.

Both architects and engineers can freely engage in concurrent design, knowing that the model always reflects the latest decisions. Design continuity is maintained because everyone “reads the same page.”

Contractors and tradespeople can be certain of having the latest documents, knowing that they will not encounter contradictory instructions or representations in them. And they have access to accurate information earlier in the project than with traditional methods, for take-offs for early estimates.

Communication is improved for all parties, since all must refer to the Virtual Building building information model.

By serving as a repository for complete building life-cycle documentation, the building information model prepares the best possible basis for facility management.

But by far the greatest gains from the use of the building information model are realized by the owner. Better designs, more efficient construction, better control over processes, and the best possible documentation for facility management—these benefits all accrue to the owner.

Fender Katsalidis—FKAU—is an architectural practice in Melbourne, Australia, known for designing functionally sound cutting-edge buildings. It is completing the Eureka Tower, a 90-story residential tower.

Implementation

Implementing the building information model, whether Graphisoft’s Virtual Building or any other, takes effort. It demands careful planning, and a significant amount of education and training for all project participants.

“By exploiting the intelligence of the 3D virtual model, we have been able to not only provide construction documentation when needed by the builder, but to prototype the design options as part of that process,” said firm principal Nonda Katsalidis.

Change is never simple. There are some who profit from existing inefficiencies, who will resist change from fear of loss. Others will resist change for its own sake. Implementing the building information model entails being prepared for such resistance, nipping it in the bud. Of course, this is a non-trivial matter; it requires careful planning, to establish and demonstrate to all parties the benefits to each in aligning their interests.

The biggest change required of the design-to-construction process by the building information model is having to complete the design and construction planning earlier than when using standard methods. Architects, in particular, are accustomed to handing over a somewhat-malleable design for construction. For the building information model to yield its greatest benefits, the design must be complete as early as possible.

Other Approaches

Other vendors, such as Autodesk/Revit and Bentley, have building-information-model systems. While a detailed comparison is beyond the scope of this white paper, we note that Graphisoft's Virtual Building is superior to these in comprehensiveness of its feature set, performance, and scalability—the result of having been conceived more than twenty years ago, and refined in real-world use over time.

The Future

The Virtual Building is as complete an approach to the automation of the construction process as can be found today. Issues remaining to be addressed in the future have to do with “closing the loop” with the construction process itself—linking to automated reporting systems in the field, so that construction progress and problems are immediately reflected in the model, without the intermediate step of manual reporting. The model then becomes the “instrument panel” for the project, reflecting in real time everything that takes place. In particular, scheduling and costing need to be addressed.

Conclusion

The building information model is a powerful new tool. Graphisoft's Virtual Building is the most complete implementation of the building-information-model concept on the market. The benefits of making the Virtual Building the central information repository for the project are numerous and substantial, for all project participants—but especially for owners.

Replacing current fragmented and redundant forms of project documentation with a building information model requires both education and training. Project participants must be educated with regard to the benefits, both to the project and to them—and they must be trained in the new workflow.

The transition to a building information model is a serious undertaking, and has to be done at the start of a project; switching in mid-stream is probably too disruptive. But the benefits are great, and the risks are low. The main challenges come in when not all project participants are willing to use the building information model. Operating in a mixed environment cancels out some of the benefits of the building information model, because of conversions, and their inherent inaccuracies. The adoption of this technology by the industry is not in question; it is a matter of “when,” not “if.” The question users must answer: Do the benefits of the building information model outweigh the costs of early adoption? For owners, we believe the answer is “yes.” For architects, builders, and design/build firms, the answer is “probably”—but careful evaluation is required.

About Cyon Research...



Cyon Research Corporation was formed by CAD industry consultants Brad Holtz, Joel Orr, and Evan Yares to foster clarity and provide vision to users and vendors of CAD and PLM tools. Current products include: CADwire.net, a leading provider of online news and analysis; COFES: The Congress on the Future of Engineering Software; Engineering Automation Report, A-E-C Automation Newsletter, Extranet News, and The CAD Rating Guide™. More information can be found at: www.cyonresearch.com, 301-365-9085.

Graphisoft partially funded our time to objectively investigate and report on the building information model. Watch for additional Cyon Research analysis of this important topic.



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