A Holistic, Integrated BIM Vision: Functional Modeling as the Key

By Mark S. Sands, PE and Mark E. Dietrick, AIA, LEED

According to the Whole Building Design Guide (WBDG), “A building information model (BIM) is a digital representation of physical and functional characteristics of a facility. As such, it serves as a shared knowledge resource for information about a facility forming a reliable basis for decisions during its life cycle from inception onward.”

Current BIM technologies, which we consider form-based, are not ideally suited to produce information at the inception of a project because they are targeted to its design stages. It is in the feasibility, planning and programming stages of a project, however, where the most impactful decisions are made regarding the scope, quality and cost of a facility.

Emerging, function-based BIM technologies are more ideally suited to produce digital representations of the physical and functional characteristics of a facility from its inception, and also to model the life-cycle information. Through data modeling, if function-based BIM can accurately simulate or re-create the program, scope and cost for actual completed facilities, it can also accurately simulate the same for a proposed facility. Within a progression of ever-tightening ranges of variation (standard deviation), the capital development and/or life-cycle results are simulated in real time, according to market averages of past projects. This new capability satisfies a critical need: more highly informed decision making starting at the very inception of a new, renovated or expanded facility.

Benefits of Integrated BIM
The integration between function and form-based BIM technologies offers a remarkable toolbox from which various options in pre-design can be explored and methodically implemented throughout the design and delivery stages. This technology and integration provides the platform from which set-based facility development (and many other Lean Construction practices needed to optimize facility performance and production) can spring. Function-based BIM includes the following benefits:

• The ability to create, at the inception of a project, highly informed program, scope and cost information for proposed facilities. Both capital development and life-cycle expense information are available in real time.
• Comparative results of different options for a proposed facility in the very early planning stages—well before significant investment in design and cost estimating efforts are expended.
• Results being reported by building systems standards (i.e., Uniformat II), but also by space designation (department, tenant, etc.) so that development and operating costs can inform the occupancy business analysis.
• Greater certainty of outcome, both in forecasting results based on actual completed historical data and the psychological motivation to beat both industry and internal standards.
- A whole-building measurement system. This creates a comprehensive measurement system throughout the supply chain and field operations—all with the aim of waste and process defect reduction and value improvement starting at the points of production.
- The empirical evidence needed to justify Integrated Project Delivery (IPD) and other advanced design and production methods.
- A measurement-based platform from which to pursue continuous improvement over many projects, rather than through traditional one-off relationships.

**Behind the Bigger Idea**

Function-based BIM actually satisfies an even greater need in the construction process than better decision making and increased certainty of outcome. It facilitates a needed breakthrough for performance and production optimization through waste elimination and value improvement that other design and delivery advancements have not been able to accomplish on most projects. It does this by submitting the whole building and major systems to measurement against standards—the most significant standard is the industry or market average.

The genesis of functional modeling comes from a need for measurement against a standard, which is necessary, ultimately, for measuring waste and process defects. This originated with W. Edwards Deming, the statistician who was instrumental in the industrial reconstruction of post-World War II Japan. Today’s Lean Construction initiative brings wonderful advancements to construction, and is based largely on Lean Manufacturing principles. One key reason that Lean Construction and Integrated Project Delivery (IPD) have not been widely adopted, however, is the lack of empirical evidence of the claims they assert. Measurement, starting at the whole building and working down into the points of production, provides this empirical evidence. Functional data modeling provides the means by which a comprehensive measurement system may be applied.

As such, the bigger idea is a transformation of the construction process that eliminates waste and improves value through program, performance and production optimization.

**Illustrating Function-Based BIM**

Through a web-based application, any user will be able to easily model a prospective facility through a menu prompt.

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**Figure 1: Program Space Selections**

*Health Center*

*Set 2—Suburban Site B* (Click to update title)

<table>
<thead>
<tr>
<th>Program Space</th>
<th>Costs</th>
<th>Schedule</th>
<th>Life Cycle</th>
<th>Optimization</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Designation</strong></td>
<td><strong>Primary Space</strong></td>
<td>Gross Space Area</td>
<td>Core and Common Area</td>
<td>Gross Building Area</td>
</tr>
<tr>
<td>Assoc.</td>
<td>Primary Space</td>
<td>52,400 SF</td>
<td>19,400 SF</td>
<td>42,000 SF</td>
</tr>
<tr>
<td>Revisions considered “Actual or Target” instead of “Approximate”</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Check here if the Gross Building Area is already determined.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primary Building Purpose</td>
<td>Medical Office Building</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Designation</strong></td>
<td><strong>Primary Space</strong></td>
<td>Gross Space Area</td>
<td>Core and Common Area</td>
</tr>
<tr>
<td><strong>Designation</strong></td>
<td><strong>Primary Space</strong></td>
<td>GSR</td>
<td>14,200 SF</td>
<td></td>
</tr>
<tr>
<td><strong>Designation</strong></td>
<td><strong>Primary Space</strong></td>
<td>Parking</td>
<td>4,400 SF</td>
<td></td>
</tr>
<tr>
<td><strong>Designation</strong></td>
<td><strong>Primary Space</strong></td>
<td>Women’s Care Center</td>
<td>5,700 SF</td>
<td></td>
</tr>
<tr>
<td><strong>Designation</strong></td>
<td><strong>Primary Space</strong></td>
<td>Child Health Group</td>
<td>3,100 SF</td>
<td></td>
</tr>
<tr>
<td><strong>Designation</strong></td>
<td><strong>Primary Space</strong></td>
<td><strong>Primary Space</strong></td>
<td>10,000 SF</td>
<td></td>
</tr>
<tr>
<td><strong>Designation</strong></td>
<td><strong>Primary Space</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Add More Space*

*Designation:*  
| **Assoc.** | **Primary Space** | **GSR** | 14,200 SF |
| **Revisions considered “Actual or Target” instead of “Approximate”** | | | |
| **Check here if the Gross Building Area is already determined.** | | | |
| **Primary Building Purpose** | Medical Office Building | | | |

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*Continued on page 20*
The first step is to define project attributes and conditions that impact program, scope and cost. Note that form-based BIM applications, in and of themselves, cannot provide this kind of vital information that may significantly impact project results. The next step is to look at the heart of the function-based model inputs. This is where the key functions (i.e., number of exam rooms, operating rooms, workstations, conference seats, classroom seats, lodging units, etc.) are input, which automatically computes a baseline (average and range) for program spaces.

"Figure 1" (see page 19) illustrates, without actually getting to each room type and count the functional modeler provides, four space program levels to define the many departments, tenants or business units within a building: (1) Principal Building Purpose, (2) Space Designation, (3) Space Category or Group and (4) Space Type or Use. At each step, a user may either accept the “market average” default or override (revise to), as more specific information is available.

Other input selections (not shown) allow the user to select qualitative measures (seismic, wind, security, continuity of operations [emergency power] and facility performance standards) to more accurately define the scope and cost. A user also has many other ways to tailor the model with more specific information as it becomes available from outside sources, such as specific design criteria that may be developed in the form-based BIM.
Results are returned in real time, and reported both by function (program designation and group) and building system (Unifromat II). The functional modeler is able to simulate (with user confirmation or revision) the scope and areas for stairs, elevators, circulation, etc., in order to build up to a complete gross building area.

The functional modeler also computes the key parametrics at the whole-building level for key physical characteristics: structural frame, horizontal and vertical exterior enclosure, interior partitions, door counts, etc. From there it will compute the cost average and ranges at four levels of detail: Whole building, Unifromat level I and II and Subsystem.

"Figure 2" (see page 20) illustrates the results for a single set, with results broken down by Space Designation and System. Further details provide more analytics to help both the owner and the building team in decision making, ultimately providing a guide for the design process.

The most powerful feature that function modeling provides is the ability to create multiple sets (scenarios and schemes, etc.). This feature provides vital information to the design team in order to make informed decisions based on comparisons; both at a summary and detailed levels. As such, "Figure 3" (see above) illustrates one of many dashboard displays that compare both the average and the variation (range of certainty) between sets.

Here, we see four of many set comparisons, showing how the planning, design and budgeting progresses. At each stage, the variation (range of uncertainty) is reduced. This feature becomes a catalyst to the Lean Construction practice of Target Value Design (TVD). As such, the owner and the building team are able to provide the design work and due diligence from baseline and benchmark targets that are more highly informed by objective "market average" data.

In concert with information derived from the web-based functional modeler, behind-the-scenes integration also occurs. Space program schedules that guide the design effort and may integrate into the form-based BIM application may be easily produced. This integration provides alignment between the two tools and allows for comparison of design to the programmatic requirements.

If special design considerations require areas to be different from the programmatic targets, outputs from the form-based BIM may be used to override the areas in the functional modeler.

Furthermore, as the design progresses to an even higher level of detail, key building system quantities, as derived from the form-based BIM, may be compared to and used as overriders to fine-tune the functional modeler predictions to an actual specific design solution. At any point, the actual design and costs may be compared to the established standards and, therefore, used as a design decisions guide and tracker of progress versus target.

ABOUT THE AUTHORS: Mark S. Sands, PE is founder of Performance Building Systems, Inc. and Building CATALYST, LLC (www.buildingcatalyst.com), Grand Rapids, MI. The mission of these organizations is to optimize space planning, building production and facility performance through measurement-driven systems. Mark E. Dietrick, AIA, LEED is director of services at Carnegie, PA-headquartered Case Technologies, Inc. (www.casetech.com), which provides comprehensive technological solutions to assist the architecture, engineering, construction and operations industry in meeting such current challenges as the demand for environmental sustainability and the movement toward tighter integration in the delivery process.