Synchronous Modeling: Including BIM in the Project Schedule

By Dr. Perry Daneshgari, Dr. Heather Moore & Phil Nimmo

The evolution of work and performance in every industry is tightly related to technology and its application. *Centralization* (when the skills are needed in one location for finishing the products), *decentralization* (when the technology allows parts and products to be produced away from the point of installation), and *recentralization* (when communication between decentralized production locations needs to become stronger and data-driven to reduce interface, tolerance, and quality issues) are phases that industries go through for scalability and mass production. Humans, technology, and data all play a role in the transition through each stage.

In construction's current state, technology can play a key role of enabling *decentralization* – resequencing the operations by modeling and optimizing the work, effort, and time for the minimum amount of rework and waste.

This article provides examples of how technologies such as building information modeling (BIM) can be used effectively when the work, effort, and time requirements of the project are managed between decentralized teams (BIM, prefabrication, material suppliers) and the onsite project team as well as models and examples of how you can use Integrated Project Scheduling™ to manage this synchronization.

CHALLENGES WITH BIM

The more work that is done away from the jobsite, the stronger the need to manage information, ultimately replacing human exchanges that no longer happen at the point of installation. Prefabrication allows more work to happen in parallel, replacing the traditional sequential approach to construction. But increasing the volume of prefabrication requires a strong process and DCI Construction® – and the recently published NEIS 5-2022[1] (construction's first standard for prefabrication written by MCA, Inc.) was developed to address this need. The same is true with BIM – the more layout, measurement, and coordination that happens on a job, the more important that information becomes to incorporate BIM's role in project planning, scheduling, and tracking.

BIM is often done by modelers who are not physically on the jobsite. They may be experts in the modeling techniques and software tools but lack the experience and knowledge of integration risk[2] in the field. Keeping them in-sync with the ongoing, ever-changing field conditions and needs is a challenge.

It is also tough for the field to stay current on what is being modeled, when, and to what level of quality as well as deal with all the changes that will impact the modeling efforts.

Although BIM may be a project requirement, the cost to model and coordinate should be seen as a means of Externalizing Work® from what would typically be done in the field; otherwise, BIM is an extra burden to the job, which can cost even more when not done well or correctly (in sync with the field).

BIM STARTS WITH B

Three-dimensional modeling in construction is nothing new; over the past couple of decades, software has helped with digital models that carry more information and allow for more virtual collaboration to speed up the process.

With these advancements in technology, it is important to recognize what is being modeled – the *building*. The model includes the physical elements that are going to be installed, with coordination theoretically done in the model rather than onsite such that the installed items end up "clash free." However, a model with zero physical clashes can still result in a costly, late, and poor-quality product onsite.

Exhibit 1 is an example of a project that required BIM from the mechanical, electrical, and plumbing trades. The electricians were spending unplanned time notching out the cable tray "to match the model," which ultimately led to a sprinkler main running directly through the electrical cable tray. The sprinkler installer didn't have an issue, but electrical productivity suffered, as work took extra time and caused delays on the project schedule.

Simply stated, *building* is not just a noun; it's also a verb. Both what is built and how it is built needs to be considered within the model. The work, effort, and time are all part of project risk (or reward) and must be incorporated.

With the fourth step of Industrialization as Modeling and Simulation,[3] modeling as translated into construction by Dr. Perry Daneshgari is described well beyond the product itself.

For example, future Modeling and Simulation in construction would help

Exhibit 1: BIM Without Work Modeling

BIM produced a model for installation that required cut outs from cable tray for a sprinkler main to run through.

Electricians had to notch out cable tray, and struggled with cable pulls in the tray, resulting in productivity losses of 50-100% on these tasks.

drive informed decisions (with data) in response to the following questions:

1. What are the optimal elements to assemble off-site?

2. What materials should show up when and where to minimize manipulations by field installers?

3. What is the optimal crew workflow in each space and time to maximize productivity?

This level of modeling and simulation requires early and structured involvement of the modelers in the project planning, scheduling, and tracking processes. In other words, *synchronous modeling* requires the on-site and off-site steps involved with modeling to happen in lockstep, which requires strict adherence to a process rather than constant back and forth via phone calls, emails, texts, etc. It requires using information that can manage that process (such as DCI Construction®) rather than *ad hoc* or spreadsheet-based tracking, etc.

The following are some steps that can be taken to make this happen:

1. Include designers from BIM in your project startup meetings.

2. Review the Work Breakdown Structure (WBS)[4] with the BIM team so they can understand the project team's plan.

3. Have BIM develop their own WBS for the approach to modeling on the project.

4. Involve BIM in any means of information management of work, effort, and time (more examples to come).

Another difference between current-state BIM in construction and step 4 of Industrialization is the *reason for modeling.* The following are purposes for modeling, as translated from outside of construction by Dr. Perry.

Note that all of these are aimed at using modeling technology to provide a visible and common understanding to enable decentralization of work.

1. Customer requirement

2. Design: for assembly, production, and installation

3. Quantification and specification

4. Packaging and logistics

5. Data-driven decision-making

In construction, BIM is often done to satisfy a customer requirement or provide a design to support assembly, production, and/or installation. In this case, the model is used to replace field work (layout and measurements) and decisions (what to prefabricate and coordination with other trades). These types of models are rigid, derived from the specifications, and conforming to the time required for installation. There is little to no consideration for optimizing the overall work, effort, and time for BIM, prefabrication, vendors, and the installation team. In other words, as long as the parts and pieces fit together, the model is used like a blueprint as a reference for installation and, in some cases, prefabrication.

Beyond satisfying customer requirements, how modeling was used in the Toyota Production System was translated to construction by Dr. Perry.[5] With this approach, a project or company would choose from predefined WBS-driven assembly and logistics packages. The model would then be used to inform decisions about who should do what, when, and where to optimize the work, effort, and time both on-site and off-site, enabling decentralization.

And, what goes in the model is not just decided by the building/component fit; it is decided based on risk and cost of poor quality in terms of either error or failure by using known designs and common assemblies. Continued use of the model allows learning and testing to optimize what happens in the field, as opposed to replacing what happens in the field with a program and modelers.

SYNCHRONOUS MODELING THROUGH INTEGRATED PROJECT SCHEDULING™

Connecting work, effort, and time in some form of a project model is not an industry norm for on-site/installation work, let alone BIM. The GC creates a project schedule that focuses on time without much consideration of the trade contractor's workforce or productivity. On the other hand, the trades focus on their work and may have a plan for the effort but never link that to the time in the schedule in which the work is to be performed.

These disconnects can lead to trade stacking, compression, and other sub-optimal results. As more work becomes decentralized from the job (via prefabrication, BIM, and vendors), the project schedule needs to include all of the contributing entities so that their impact on each other can be managed throughout the project. This is done through Integrated Project Scheduling™, where the project schedule includes activities from and logic links to off-site resources so they can see, have input to, and keep up with changes from the onsite construction and final installations.

This integration process doesn't require any new tools; it's all about information and planning, which starts with the WBS. When you create the WBS and identify the tasks that will involve BIM design, coordination, and/or prefabrication in the shop, that's the time to start framing up the actual work and timeline to do that off-site work. BIM and prefabrication require a series of activities and preparation in order to proceed and produce a correct deliverable at the prescribed time.

Exhibit 2 shows an example of these types of tasks in a WBS. The overall activities for BIM and for many prefabrication assemblies will be common across projects. Therefore, a common WBS can be used to integrate into the project schedule. An example would include such tasks and consideration for logic in the project schedule, such as:

• Identify the BIM/prefabrication requirements with a resource, duration, and estimated labor hours.

• For the work to be completed externally, what are the BIM requirements, material requirements, and lead times for the materials from the selected vendors?

• In order for the vendor to have time to secure the materials and ship them, when will purchase orders and release paperwork be required?

• How long after the materials arrive and the design is complete will it take to produce any items in prefabrication?

• After prefabrication is complete, how long will it take to ship these to the jobsite and position them at the point of installation?

Integrating these tasks and considerations into your existing project schedule in a way that connects them to the installation tasks and requirements forms an effective project model, which requires a lot of careful planning. The software tools are very helpful, but decisions will still need to be made.

For example, the Integrated Project Schedule™ will require answering the following questions:

1. Which tasks can be performed in parallel? Which tasks need to be sequential?

2. How much lead and lag time needs to occur within the task items in order to keep the work progressing and the manpower reasonably leveled?

3. Which tasks are resource driven, and specifically how many people will be assigned to the work? If that number increases or decreases, then how will that impact the duration to complete?

Once the schedule model is in place, then the necessary people, material, and tool resources can all be planned and scheduled with proper lead times. The single greatest value of all this planning and scheduling is that once the model is in place – with the correct details and connections – then you have the tool that is needed to respond to change requests in a timely manner.

When something changes on the jobsite, either from the overarching GC schedule or in any of the trade work, the Integrated Project Schedule™ allows a contractor to understand the quantitative impacts within hours or days from when changes are announced. Even changes that may appear to be weeks or months out from today can be modeled to understand how they will impact prefabrication, BIM, and procurement.

In a *centralized* work environment, this is less critical because all of the resources needed to respond to the change are on the jobsite. However, in the decentralized environment of construction, the changes have to be made visible with data and information.

Exhibit 2: Sample WBS for BIM

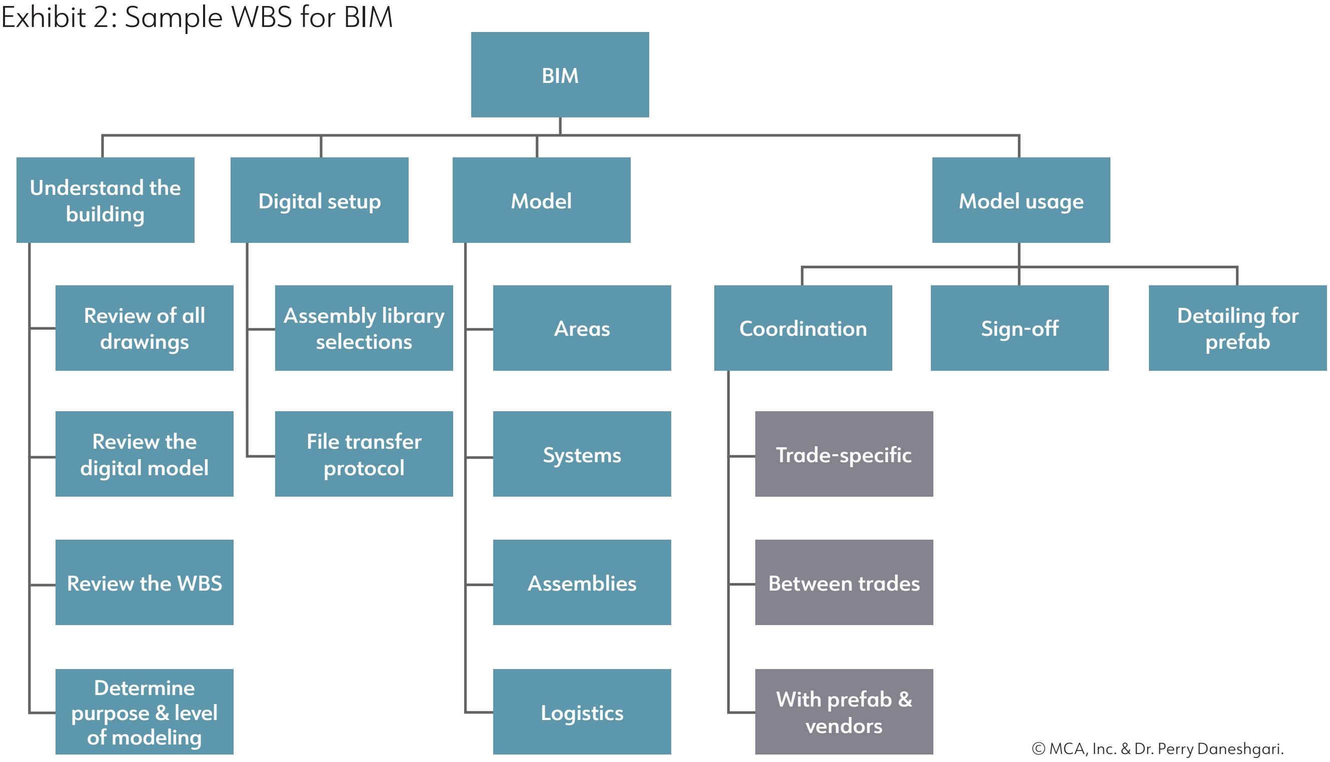

Exhibit 3 is adapted from an actual project schedule and shows how BIM design and coordination tasks are included as predecessors to the subsequent prefabrication, delivery, and installation activities. It also shows that the installation tasks on the jobsite with required effort are connected to the GC's scheduled time for the subcontractor to work within the area.

Changes in sequence from the GC often impact the subcontractors' flow of work in design, prefabrication, and installation. The absence of an effective model to quickly determine the overall impacts in every area will leave subcontractors unable to provide timely and accurate responses when changes are received.

Project schedule changes can also lead to insufficient time to complete the intended BIM and prefabrication work, so the field team simply bypasses the Externalized Work® and builds what they need on site.

By having the project model that includes work, effort, and time for all contributing parties to installation, a change in schedule can be evaluated for its impact to the project's productivity, cost, and timing. Without an integrated approach, the project team will make the decision that seems best for them in the moment without having the data to do otherwise.

This simple scheduling technique – recognizing Externalized Work® as part of the overall project plan and schedule – will save stakeholders money on their projects and is the most effective way to reduce litigation costs and delays using tools and techniques currently available to all contractors.

CONCLUSION

The current centralized work of the construction jobsite space and time will be able to decentralize through the process of WBS for managing labor and managing work. BIM and prefabrication technologies can allow more work to happen away from the jobsite, but it requires careful management and synchronization of information.

By incorporating BIM into project schedules and connecting it with other activities, changes and impacts can be assessed quickly, leading to cost savings, improved productivity, and reduced delays. **BP**

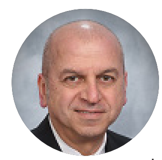

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Exhibit 3: Including BIM Work & Effort in Time Integrated Project Schedule™

Task Name	Work	Duration	Start	Finish	% Complete	Predecessor
Roof	**1,076h**	**68d**	**Fri 5/12/23**	**Tue 8/15/23**	**0%**	
BIM Coordination Area Elec Closet/Panels/OH Feeders	0h	10d	Fri 5/12/23	Thu 5/25/23	0%	208SS
SO to Detailed Drawings	0h	0d	Thu 5/25/23	Thu 5/25/23	0%	934
Detailing to Prefab	0h	0d	Thu 5/25/23	Thu 5/25/23	0%	935
Prefab Production	0h	10d	Fri 5/26/23	Thu 6/8/23	0%	936
Prefab Delivery	0h	0d	Thu 6/8/23	Thu 6/8/23	0%	937
GC Task – L6 Ballroom High Roof	0h	20d	Wed 6/14/23	Tue 7/11/23	0%	
GC Task – L6 Ballroom High Roof	0h	25d	Wed 6/14/23	Tue 7/18/23	0%	
Contractor A	**758h**	**20d**	**Wed 7/19/23**	**Tue 8/15/23**	**0%**	
Feeder Rough	528h	20d	Wed 7/19/23	Tue 8/15/23	0%	940
Feeder Cable	140h	20d	Wed 7/19/23	Tue 8/15/23	0%	940
Distribution Equipment	90h	20d	Wed 7/19/23	Tue 8/15/23	0%	940
Contractor B	**318h**	**5d**	**Wed 7/19/23**	**Wed 7/25/23**	**0%**	
Branch Rough	124h	5d	Wed 7/19/23	Wed 7/25/23	0%	940
Branch Wiring	172h	3d	Wed 7/19/23	Fri 7/21/23	0%	940
Devices	22h	1d	Wed 7/19/23	Wed 7/19/23	0%	940

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Endnotes

1. *"NECA 5 – 2022 Standard." MCA, Inc. mca.net/about-us/neca-5-2022-standard.*
2. *Daneshgari, Dr. Perry; Moore, Dr. Heather; & Daneshgari, Jennifer. "PMs & CFMs: Increase Information-Sharing to Improve Profitability." CFMA Building Profits. March/April 2021. cfmabponline.net/cfmabp/20210304/MobilePagedArticle.action?articleId=1669332#articleId1669332.*
3. *Moore, Dr. Heather & Parvin, Sydney. "How Industrialized Are You? Measuring Your Company's Progress." CFMA Building Profits. November/December 2021. cfmabponline.net/cfmabp/11122021/MobilePagedArticle.action?articleId=1743447#articleId1743447.*
4. *Daneshgari, Dr. Perry & Moore, Dr. Heather. "The Operational Model for Modular Construction." CFMA Building Profits. May/June 2020. cfmabponline.net/cfmabp/20200506/MobilePagedArticle.action?articleId=1656009#articleId1656009.*
5. *Daneshgari, Dr. Perry; Moore, Dr. Heather; & Daneshgari, Jennifer. "PMs & CFMs: Increase Information-Sharing to Improve Profitability." CFMA Building Profits. March/April 2021. cfmabponline.net/cfmabp/20210304/MobilePagedArticle.action?articleId=1669332#articleId1669332.*