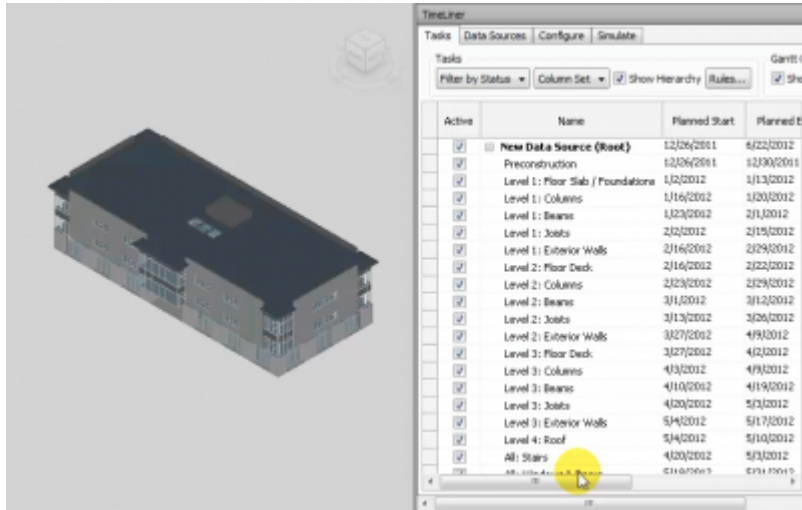


4D Simulation and Construction Planning



In this lesson, students explore how to use 4D simulation to support construction planning and assess the impact of proposed design features on the construction schedule and workflow. This feedback provides valuable information to inform decisions as project teams evaluate and assess potential design features and construction options.

Students will learn how to use a workflow combining models created with the Autodesk® Revit platform with the Autodesk Navisworks® TimeLiner tool to create 4D simulations of planned construction processes. They will explore modeling techniques for creating better and more accurate simulations, as well as the importance of modeling building elements to reflect planned construction techniques. They will also learn to use Revit features, such as project and shared parameters, to add information to building model elements that supports additional uses of the data in the building model—in this case, for materials tracking and management.

Applications of BIM Models for Construction Process Planning

Using the Autodesk® Revit platform in combination with Autodesk Navisworks® Manage creates a workflow that enables project teams to effectively plan construction operations, identify potential problems, and explore and evaluate alternatives. Using these tools, construction planners can simulate planned sequences of construction activities, identify clashes and interference problems, find opportunities for improving construction schedules, track materials and manage the supply chain, and much more.

Some suggested applications of BIM for construction planning include:

- **4D Modeling**—simulating the planning sequence of construction activities and space requirements on a building site.

4D modeling provides a powerful visualization and communication tool that gives project teams (including owners and building users) a better understanding of project milestones and construction plans. 4D simulation can help teams identify problems well in advance of construction activities, when they are much easier and less costly to resolve.

4D models can also be used to plan the phased occupancy in a renovation, retrofit, addition. Creating dynamic phasing plans of occupancy enables multiple options and solutions to space conflicts to be considered and evaluated.

- **Site Utilization Planning**—using BIM models to evaluate the locations of both permanent and temporary facilities on site during multiple phases of the construction process.

BIM models can be linked with construction activity schedules to explore space and sequencing requirements. Additional information describing equipment locations and materials staging areas can be integrated into the project model to facilitate and support site management decisions, enabling project teams to effectively generate and evaluate layouts for temporary facilities, assembly areas, and material deliveries for all phases of construction.

- **3D Coordination and Clash Detection**—identifying potential conflicts by comparing 3D models of all building systems.

The goal of clash detection is to reduce and eliminate field conflicts, which in turn reduces RFI's, reduces construction cost, and increases productivity on site.

- **Identifying Time-Based Clashes**—verifying the planned sequence of construction operations on constrained sites to confirm that the demolition, permanent construction, and temporary construction activities can occur without creating conflicts.

Time-based clash testing provides valuable insights for construction planners as they coordinate the trades, materials, and equipment that must coexist in the limited space available. Construction planning models can be integrated with the composite project model and linked to the project timeline to consider the impact of temporary items (such as work packages, formwork, cranes, installations, and so on) and check for potential time-based clashes.

- **Construction System Design (Virtual Mockups)** —creating a model to design and analyze the construction of a complex building system (for example, formwork, glazing, tie-backs, and so on) to support detailed construction planning.

Creating virtual mockups of a construction system design can increase the constructability of a complex building system and construction productivity on site by effectively planning and communicating the complexities of the process to all participants.

- **Materials Planning and Management**—using 4D modeling and links between the building elements in the project model and the associated task schedule to forecast the dates when elements are needed on site for installation.

Parameters can be added to the elements in the project model to track their ordering and delivery status and manage the supply chain for materials needed on site.

Creating 4D Simulations

By linking timelines of project tasks to model elements, we can create a complete 4D simulation of the construction process from the demolition phase through owner move-in. This simulation can be used to inform critical planning decisions about construction methods, resource allocation, activity sequencing, site space utilization, and so on.

Using the Navisworks TimeLiner tool, project teams can simulate construction processes by:

- Manually enter information about project tasks or import schedules from many project planning software applications.
- Link elements in the composite model with tasks in the schedule.
- Simulate the schedule and viewing the effects on the model, including planned versus actual schedules.

To simplify this process on large and complex projects, it is common to include key building elements in the 4D simulation and omit less important features. The primary elements that are typically required in 4D simulations include:

- Structural system—structural framing components including foundations, grade beams, columns, load bearing walls, floor and roof decks and support.
- Exterior building envelope—stud wall, exterior panels and assemblies, curtain walls, openings, and glazing.
- Interior partitions—main interior walls, plumbing walls, and wall assemblies.
- Mechanical systems—main ductwork and equipment, separated by floors.
- Roof systems—roof assemblies, major equipment, and openings.
- Site work—excavation work, footings, foundations, and slabs on grade.
- Plumbing systems—main connection lines from site and main plumbing lines.

Maximizing the Effectiveness and Value of 4D Simulations

In order to create accurate and truly useful 4D simulations, it is critical that building elements be model in a way that mirrors the actual construction process planned. Strategies for doing this include:

• **Using Parts to Schedule the Layers of an Element Independently**

Building elements with structures composed of multiple layers that will be installed at different times (e.g. the core structural layers of a wall assembly versus the interior and exterior finish layers) should be decomposed into parts to allow accurate scheduling of individual layers.

Scheduling the original multi-layer element can create simulation errors (interior and exterior finishes being installed at the same time as the structural core), and this inaccuracy diminishes the value of the simulation for detailed construction planning.

• **Splitting Larger Elements to Model Location-Based Scheduling**

Large, continuous building elements that will be installed in smaller pieces (e.g. long wall sections that span the entire face of the building) should be split into segments that match the actual construction process.

Creating overly lengthy tasks to match the building elements builds artificial delays into the simulation and diminishes its value as a planning tool. It is better practice to subdivide the elements into realistic chunks that match actual construction activities.

This approach is commonly used to support location-based scheduling—a strategy that attempts to create smooth, parallel workflows of sequential construction tasks through project locations by adapting the work crews and planned activities to minimize conflicts and delays created by location unavailability.

Advantages of 4D simulation

The ability to forecast and anticipate problems before they occur is essential for effective project management. When the cost of schedule delays or construction rework because of errors is considered, it is clear that project managers need to carefully plan and orchestrate construction operations down to the last detail, both in space and time.

Traditional scheduling methods do not address the spatial aspect to the construction activities nor are they directly linked to a design or building model. Traditional bar charts or Critical Path Method network diagrams can be difficult to understand or interpret. Having the ability to watch the elements of a design come together onscreen gives the design and construction team improved accuracy in construction sequencing.

4D simulation enables project teams to:

- Inform design decisions by considering the impact on construction of proposed design features.
- Identifying and resolving problems earlier (when needed changes are easier and less costly to implement).
- Access and manage project risks.
- Improve project schedules and bring facilities online sooner, which is typically a great benefit to the owner and users.

Additional Resources

Online

- [BIM Execution Planning Website](#) [1]
- [GSA BIM Guide Series: 3D-4D-BIM Overview](#) [2]
- [4D CAD Research Group](#) [3]
- [3D and 4D Modeling for Design and Construction Coordination: Issues and Lessons Learned](#) [4]
- [Benefits and Lessons Learned of Implementing Building Virtual Design and Construction \(VDC\) Technologies for Coordination of Mechanical, Electrical, and Plumbing \(MEP\) Systems on a Large Healthcare Project](#) [5]

- [Decomposition of BIM objects for scheduling and 4D simulation](#) [6]
- [Autodesk Navisworks Animated Construction](#) [7]
- [Autodesk Navisworks 2011 Construction Animation](#) [8]
- [Scheduling and 4D Simulation - Autodesk BIM Curriculum or Architecture, Engineering, and Construction Management Curriculum, Unit 5, Lesson 3](#) [9]
- [Identifying and Resolving Issues - Autodesk BIM Curriculum or Architecture, Engineering, and Construction Management Curriculum, Unit 5, Lesson 2](#) [10]
- [Navisworks Simulate Online Help](#) [11]
- [Navisworks Manage User Guide](#) [12]
- [Autodesk BIM for Construction Screenshots - Autodesk Resource Center for Construction Professionals](#) [13]

Publications

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- Haymaker, J., & Fischer, M. (2001) Challenges and Benefits of 4D Modeling on the Walt Disney Concert Hall Project. CIFE Working Paper #64, Stanford University
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- Hartmann, T., Gao, J., and Fischer, M. (October 2008) Areas of Application for 3D and 4D Models. Journal of Construction Engineering and Management, n.135, issue 10, p.776-785.

WikiHelp

Shared Parameters

- Setting Up Shared Parameter Files
- Adding Shared Parameters to Families
- Shared and Family Parameters
- Tagging with Shared Parameters
- Schedules with Shared Parameters

Project Parameters

- Creating Project Parameters
- Creating Shared Project Parameters
- Reporting Parameters

Schedules

- Creating a Schedule or Quantity
- Specifying Schedule Properties
- Applying a Phase to a Schedule
- [Modifying Schedules](#) [14]
- Reusing Schedule Views
- Exporting a Schedule

Formulas

- Resizing Elements with Formulas
- Using Formulas for Numerical Parameters
- Valid Formula Syntax and Abbreviations
- [Conditional Statements in Formulas](#) [15]

Exporting to Navisworks

- Enable Navisworks Switchback in Revit
- [Export Revit element textures to Navisworks](#) [16]
- Export Revit Parts to Navisworks

Source URL:

<http://auworkshop.autodesk.com/library/bim-curriculum-construction/4d-simulation-and-construction-planning>

Links

- [1] <http://bim.psu.edu/>
- [2] <http://www.gsa.gov/portal/content/102276>
- [3] <http://www.stanford.edu/group/4D/>
- [4] http://www.itcon.org/data/works/att/2007_26.content.07145.pdf
- [5] http://www.itcon.org/data/works/att/2008_22.content.04920.pdf
- [6] <http://www.inpro-project.eu/media/DecompositionBIM.pdf>
- [7] <http://www.youtube.com/watch?v=tQkDRXo7tLM&feature=related>
- [8] <http://www.youtube.com/watch?v=kAZTUEDMrF4&feature=related>
- [9] <http://www.bimtopia.com/bimcurriculum/unit-5/lesson-5-3.html>
- [10] <http://www.bimtopia.com/bimcurriculum/unit-5/lesson-5-2.html>
- [11] <http://docs.autodesk.com/NAVSIM/10.0/ENU/Autodesk%20Navisworks%20Simulate%202013%20Online%20Help/index.htm>
- [12] <http://www.autodesk.com/navisworksmge-userguide-2013-enu>
- [13] <http://usa.autodesk.com/adsk/servlet/index?id=16087143&siteID=123112>
- [14] http://wikihelp.autodesk.com/Revit/enu/2012/Help/Revit_User's_Guide/1394-Document1394/1476-Schedule1476/1517-Modifyin1517
- [15] http://wikihelp.autodesk.com/Revit/enu/2012/Help/Revit_User's_Guide/2654-Tools_an2654/2894-Formulas2894/2898-Condition2898
- [16] http://wikihelp.autodesk.com/index.php?title=Revit/enu/Community/Tips_%26_Tricks/Import,_Export,_Layers/Export_Revit_element_textures_to_Navisworks

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