Practical 4D Construction Simulation Using Revit and Navisworks

Ken Flannigan
Global BIM Solution Owner, KONE
Timing

• 25 minutes – What and Why
• 25 minutes - Demonstrations
• 10 minutes - Q&A
About the speaker

Ken Flannigan
KONE Global BIM Solution Owner since 2016
Live in Frisco, Texas
Started career in architecture, spent 10 years as consultant and trainer
LEED AP
Today, most BIM coordination uses geometry in its final installed position.

What are we missing?
Construction Modeling and Simulation
90% of 4D use is:

“Hollywood BIM”

BIM deliverables, images, and animations made for entertainment purposes only. Also, NOT what we are interested in.

https://commons.wikimedia.org/wiki/File:Aerial_Hollywood_Sign.jpg
We use “Hollywood BIM” too
Let’s remember back, how it all started…

The Year was 2008.

…The United Nations designated 2008 as the International Year of the Potato.

…The price of a movie ticket was $7.00

…Global stock prices plunged to record lows and the Dow Jones Industrial Average lost 33.8% of its value.

…The most popular song was Low by Flo Rida with T-Pain

We were just beginning our 3D coordination journey

We coordinated what we could, we modeled items outside of our scope to understand design and construction better
What are your problems?

Can we understand them better virtually?
Practical 4D Construction Simulation

SITE LOGISTICS MODELING
3D models of clear work areas, material laydown areas, delivery and staging areas

EQUIPMENT ROUTING ANIMATION
Animation of an object that needs to be moved from a delivery or staging area into its installed position.

PROJECT TIMELINE SIMULATION
Animation showing building elements changing visual properties, usually color and transparency, during a series of tasks.
Site Logistics

• Improving communication of onsite material storage and clear work area requirements

• Coordinate equipment installation sequencing

• Communicate and optimize the space needed by multiple trades during construction
Site Logistics is usually communicated in a site readiness guide or checklist.
What Does Site Logistics Modeling Enable?

PROJECT SEQUENCING DISCUSSION
Communicate the space needed during installation to help guide the sequence of construction / equipment installation.

ONSITE MATERIAL STORAGE OPTIMIZATION
Placing onsite storage required areas in optimal locations may mean we spend less labor hours onsite.

PLAN FOR MULTIPLE DELIVERIES
While we require a certain space per installation, we almost never get that space. Here we can use the 3D model to realistically plan for multiple deliveries.

3D/4D CONSTRUCTION SITE SPACE PLAN
If all trades are modeling their construction-time space requirements, there is an opportunity to computationally solve for an optimized sequence the same way generative design tools allow for early design optimization.
What Does a Site Logistics Model Look Like?
Site Logistics in Revit and Navisworks

**REVIT**
1. Link Equipment models and architectural/structural models
2. Copy important levels and Acquire Coordinates
3. Place the site logistics components on each level, as required
4. Hide Linked models and export 4D Site Logistics model to desired format (DWF)

**NAVISWORKS**
1. Append the site logistics model exported from Revit, we use DWF or IFC.
2. Isolate building floors with site logistics using sectioning tools.
3. Save Viewpoint(s)
4. If necessary, select the object and use the Item tools to Move, Rotate, or Scale
5. Screen capture or export image formats.
Equipment Routing

- Improve installation planning by animating the path and associated equipment and rigging
The way it was done before,
Rig & Hoist

- Installation with rolling A-frames:
Rig & Hoist

- Installation with rolling A-frames:

Level 300

Level 250

Column 32.5
Rig & Hoist

• Installation with rolling A-frames:
Rig & Hoist

• Installation with rolling A-frames:
Rig & Hoist

• **Installation with rolling A-frames:**

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**Column 32.5**
• Installation with rolling A-frames:
Rig & Hoist

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• **Installation with rolling A-frames:**

![Diagram of Rig & Hoist installation with rolling A-frames]

- Column 32.5
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- Installation with rolling A-frames:
• **Installation with rolling A-frames:**

![Diagram of Rig & Hoist installation with rolling A-frames]
• Installation with rolling A-frames:
Good Luck
When You Use 3D To Simulate That Solution:
Let’s Simulate A Better Plan…

Option1: Single truss installation if sequenced before upper steel is erected
OR...

Option 2: Split truss installation if sequenced after upper steel (red) is erected
Equipment Routing in Revit and Navisworks

**REVIT**
1. Use the Site logistics model as a starting point, if available.
2. Insert onsite construction equipment to be used in routing
3. If adding rigging elements to an item, use an In-Place model to generate a simplified version of the crane rigging, as necessary to more completely represent the size of the routed equipment.

**NAVISWORKS**
1. Move the time bar to the starting keyframe (~40 seconds in)
2. Capture a key frame – this represents the end of the animation
3. Move the time bar earlier (2-5 seconds) so now we are at the time 35 – 38 seconds
4. Choose one or more transform and move the equipment animation set to the condition representing the culmination of movement and/or visibility changes from the previous key frame.
5. Capture a key frame.
6. Repeat steps 3-5 until the position and/or visibility of the equipment animation set is in its starting position.
7. Play the animation and re-positon each keyframe to achieve a pleasant speed.
Timeline Simulation

- Animation of the overall construction process and can/should include site logistics geometry and equipment routing animations.
Practical Timeline Simulation

WHAT IT IS

• High level tasks representing major milestones
• Site logistics components appear as temporary tasks
• Model Text geometry representing milestones not easily communicated through equipment model geometry

WHAT IT IS NOT

• Minute-by-minute work plan that we may use internally to measure performance of an installation team
• Photorealistic animations of all elements on a construction site.
Timeline Simulation in Revit and Navisworks

REVIT
1. Working in a 4D template, use model text based component to add notes to the 4D model
2. Position the model text component outside of the building model in an easily viewed area from the standard isometric views.

NAVISWORKS
1. Create tasks
2. Add start /End dates
3. Set the Task type:
   a) Construct – For equipment elements to be installed
   b) Temporary – For site logistics geometry only used during construction
4. Attach selection and animation
5. Simulate to customize, preview and export the animation
Revit 4D Project Setup
1. Creating a 4D Project File
2. Customizing the model for equipment routing
3. Placing site logistics and key milestone indicators
4. Exporting to Navisworks

Navisworks 4D Workflows
1. Adding 4D models to Navisworks
2. Managing Viewpoints
3. Animating equipment routing
4. Creating a Construction Timeline
https://knowledge.autodesk.com/community/screencast/cee14ab5-b6f0-4448-9de0-5f44eb441c4f
1. Elevator Equipment Delivered

https://knowledge.autodesk.com/community/screencast/cf4ae762-0003-4cdd-bf4b-7e27380b3ff8
1. Elevator Equipment Delivered
2. Pit Work Starts
3. Elevator Tops Out
4. Control Room Complete
5. Elevator Group Complete

https://knowledge.autodesk.com/community/screencast/641cdfb0-6a8f-4720-9be7-dc0968a8383e
Loading and appending to Navisworks Manage 2019 – Untitled

https://knowledge.autodesk.com/community/screencast/1d1085df-74f1-47fd-a7dc-63af5895d4ba
1. Elevator Equipment Delivered
2. Pit Work Starts
3. Elevator Tapes Out
4. Control Room Complete
5. Elevator Group Complete
Add Animation to Timeliner – Navis 7

https://knowledge.autodesk.com/community/screencast/e12f1110-3fb6-4ff0-b8e4-0e8a44f1415c
Practical 4D – Building The Digital Construction Site

- **Site Logistics Models**
  - Equipment Routing Animations
    - Use Delivery staging and onsite material storage from Site Logistics Model in Equipment Routing Animations
    - Include Delivery staging and onsite material storage (Temporary task type) + include equipment routing animation in timeline task

- **Project Timeline Simulation**
What’s Next?
### 4D Construction Digital Twin

<table>
<thead>
<tr>
<th>Simulative Planning</th>
<th>Real-time feedback</th>
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<tbody>
<tr>
<td>• Space planning the construction site</td>
<td>• 3D virtual model container for vast and growing sensor data</td>
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<tr>
<td>• Starts with Site logistics modeling</td>
<td>• Reality capture provide spatial progress data to update/compare 3D</td>
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<tr>
<td>• Computational solving similar to building program optimization</td>
<td>virtual model</td>
</tr>
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<td></td>
<td>• Foundation of operational digital twin</td>
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Parting Thoughts

- Expect BIM Coordination from elevator/escalator contractor
- Consider value of all trades modeling construction-time requirements
- Include 4D project requirements for specific use cases (e.g. large equipment routing)
Thank you.

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