NAC Executive Insights

Quantity Takeoffs in AI Enabled Digital Twins

Key Points

- Approach for generating a quantity takeoff from a digital twin model is outlined.
- Comparison of AI-enabled digital twin quantity takeoff software is provided.
- Quantity takeoffs on large complex projects addressed.

Introduction

The growing use of digital twins opens new avenues for quantity takeoffs especially as artificial intelligence (AI) capabilities are integrated into associated software. In this Executive Insight we:

- look at a step-by-step approach for generating a quantity takeoff from a digital twin model
- compare the AI and broader features of three popular quantity takeoff tools that integrate with BIM software
- take a deeper dive into one which appears to be the best choice for quantity takeoffs on large complex projects

This Executive Insight is intended as a companion piece to the Executive Insight entitled “Adoption of Artificial Intelligence in Quantity Takeoffs in Engineering & Construction Organizations”

Step-By-Step Approach for Generating a Quantity Takeoff from A Digital Twin Model

Generating a quantity takeoff from a digital twin model holds several advantages over more traditional quantity takeoff processes, including those which have been AI enabled. These advantages are discussed later in this Executive Insight. The step-by-step approach can be summarized as follows:

1. Create the Digital Twin Model:
    - **Gather Data:** Collect all necessary data, including architectural, structural, and MEP (Mechanical, Electrical, and Plumbing) designs.
    - **Build the 3D Model:** Use BIM (Building Information Modeling) software to create a detailed 3D model of the project. Tools like Autodesk Revit or Navisworks are commonly used.
    - **Integrate IoT Sensors:** Link IoT sensors to the model to capture real-time data, ensuring the digital twin reflects the current state of the physical asset.
2. Set Up the Takeoff Tools:
    - **Select Software:** Choose a quantity takeoff tool that integrates with your BIM software. Examples include Autodesk Navisworks, Bluebeam Revu, or Trimble Connect. The features of each of these are described in the table starting on page 3.

    - **Configure Settings:** Set up the software to recognize the elements and materials in your digital twin model. This may involve defining measurement units, material types, and other parameters.
3. Extract Quantities:
    - **Automated Extraction:** Use the takeoff tool to automatically extract quantities from the digital twin model. The software will identify and measure elements such as walls, floors, windows, and doors.
    - **Manual Adjustments:** Review the extracted quantities and make any necessary manual adjustments to ensure accuracy. This step is crucial for complex or custom elements that may not be fully captured by the automated process.
4. Generate Reports:
    - **Create Detailed Reports:** Generate detailed quantity takeoff reports that include all measured elements and their quantities. These reports can be customized to meet specific project requirements.
    - **Export Data:** Export the data to formats such as Excel, PDF, or directly into project management software for further analysis and use.
5. Validate and Update:
    - **Cross-Check Quantities:** Validate the extracted quantities by cross-checking with the original design documents and on-site measurements.
    - **Update Model:** Continuously update the digital twin model with new data from the construction site to ensure it remains accurate and up to date.

By following these steps, you can effectively generate accurate and efficient quantity takeoffs from a digital twin model.

Benefits of Using Digital Twin for Quantity Takeoffs

Digital twins provide a range of benefits in quantity takeoffs including:

- **Real-Time Accuracy:** Provides up-to-date and accurate quantity takeoffs based on the latest project data.
- **Efficiency:** Reduces manual effort and speeds up the takeoff process.
- **Visualization:** Offers a visual representation of the project, making it easier to understand and verify quantities.
- **Integration:** Seamlessly integrates with other project management tools and systems.

Comparison of AI-Enabled Digital Twin Quantity Takeoff Software

This Executive Insight focuses on three common AI enabled software tools used in quantity takeoffs from digital twin models. They include Autodesk Navisworks, Bluebeam Revu, and Trimble Connect. The following table provides a comparison of features and functionality of each.

Comparison of AI-Enabled Digital Twin Quantity Takeoff Software			
Features	**Autodesk Navisworks**	**Bluebeam Revu**	**Trimble Connect**
AI & Search			
AI Features	Clash Detection: Uses AI to identify and resolve clashes, which helps in accurate quantity takeoffs by ensuring no overlapping elements are counted. Automated Symbol Detection: Automatically detects and counts symbols in drawings, streamlining the takeoff process.	Visual Search: Uses AI to identify and count visual elements in PDFs, which is particularly useful for quantity takeoffs from 2D plans. Text Recognition (OCR): Converts scanned PDFs into searchable text, making it easier to extract quantities from text-based documents. Batch Processing: Automates repetitive tasks for large sets of drawings, improving efficiency in the takeoff process.	3D Deep Learning: Automatically classifies and segments point clouds, which can be used to extract quantities from 3D scans. Generative AI: Combines models with text prompts for realistic renderings, potentially aiding in visualizing and estimating quantities. Feature Extraction: Uses AI for automated classification and feature extraction from complex data, streamlining the takeoff process.
Image Search	Search Sets: Allows creating intelligent groups of objects based on properties, aiding in the organization and retrieval of specific elements for takeoffs.	Visual Search: Allows searching for visual cues or objects within a document, aiding in the identification and counting of elements for takeoffs.	Visualization Tools: Provides tools for viewing and interacting with 3D models but lacks a dedicated image search feature.
Text Search	Find Items: Enables searching for specific properties and elements within the model, useful for locating items quickly	Text Search: Searches for text within PDFs, including metadata and form fields, which helps in quickly locating relevant	Data Management: Manages project data and documents but does not have advanced text search capabilities like OCR.

Comparison of AI-Enabled Digital Twin Quantity Takeoff Software			
Features	**Autodesk Navisworks**	**Bluebeam Revu**	**Trimble Connect**
	during the takeoff process.	information for estimating.	
GPT Integration	No direct integration with GPT models but can be used in conjunction with other Autodesk tools that may leverage GPT for enhanced functionalities.	No direct integration with GPT models, but Bluebeam Labs is exploring AI innovations that could include advanced text and image processing.	No direct integration with GPT models, but Trimble is exploring AI applications that could enhance data analysis and decision-making.
Functionality			
Cloud-Based Features	While Navisworks itself is primarily a desktop application, it integrates with Autodesk Construction Cloud and BIM 360 for cloud-based collaboration and data management.	Bluebeam Revu offers cloud-based collaboration through Bluebeam Studio.	Trimble Connect is a fully cloud-based platform.
Cloud Based Usage	These integrations allow users to share models, collaborate in real-time, and manage project data in the cloud.	Bluebeam Studio enables real-time document sharing, markup, and collaboration, allowing multiple users to work on the same document simultaneously from different locations.	It facilitates real-time collaboration, data sharing, and model viewing directly in the cloud, making it accessible from anywhere with an internet connection.
Curve Takeoff on Linears	Supports linear takeoffs through its Quantification tool, but primarily focuses on 3D model-based takeoffs.	Supports linear takeoffs through its measurement tools, with cloud-based collaboration via Bluebeam Studio.	Supports linear takeoffs through integration with other Trimble tools.
Split Tool	Allows split screen views to compare different viewpoints	Allows split views to compare different sections of a document.	Allows viewing multiple sections of a model simultaneously.

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	or phases of the model.		
Merge Tool	Can append and merge multiple files into a single project, removing duplicate geometry and markup.	Can merge multiple PDFs into a single document.	Can merge multiple models and data sets into a single project.
Real-Time Internal Collaboration	Integrates with Autodesk BIM Collaborate for real-time collaboration within teams.	Bluebeam Studio enables real-time collaboration within teams on the same document.	Facilitates real-time collaboration within teams through cloud-based model sharing.
Real-Time External Collaboration	Supports external collaboration through BIM 360 and Autodesk Construction Cloud, allowing shared views and issue tracking.	Supports external collaboration through Bluebeam Studio, allowing multiple users to work on the same document simultaneously.	Supports external collaboration by allowing stakeholders to access and interact with models in real-time.
User Permissioning and Management	Provides robust user permission settings through integration with Autodesk Construction Cloud.	Offers detailed user permission settings within Bluebeam Studio.	Provides detailed user permission settings to control access and editing rights.
Export Filtering	Allows filtering of exported data to include only relevant information.	Allows filtering of exported data to include only relevant information.	Allows filtering of exported data to include only relevant information.
Drawing	Supports 2D and 3D drawing takeoffs and markups.	Provides robust drawing and markup tools for PDFs.	Supports drawing and markup tools for 3D models.
Revision Management	Tracks revisions and updates in models, ensuring all changes are documented.	Tracks revisions and updates in documents, ensuring all changes are documented.	Tracks revisions and updates in models, ensuring all changes are documented.
Auto Drawing Naming	Does not have a specific auto-drawing naming feature but integrates well with other Autodesk tools that may offer this.	Supports custom naming conventions for drawings and documents.	Supports custom naming conventions for drawings and models.

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Features	**Autodesk Navisworks**	**Bluebeam Revu**	**Trimble Connect**
Floor Plan AI Area Takeoff	Supports area takeoffs using 2D takeoff tools. Users can mark-up line geometry on a floor plan to record areas.	Provides area measurement tools for marking up PDFs and calculating areas.	Supports area takeoffs through integration with other Trimble tools.
Floor Plan AI Linear Takeoffs	Allows linear takeoffs by tracing linear markups to measure walls or perimeters of rooms.	Includes linear measurement tools for measuring lengths and perimeters.	Allows linear takeoffs by measuring lengths and perimeters in 3D models.
Floor Plan AI Count Takeoffs	Enables count takeoffs by placing markup pins on 2D sheets to count elements.	Offers count tools to tally items on floor plans.	Enables count takeoffs by identifying and counting elements in models.
Snapping to Points	Provides snapping to vertices, edges, and lines to ensure precise measurements.	Supports snapping to points, lines, and objects for precise measurements.	Provides snapping to points, lines, and surfaces for accurate measurements.
Organization Library	Uses the Quantification workbook to organize and manage takeoff data.	Uses Tool Chest to organize and manage tools and markups.	Uses a centralized library to manage project data and elements.
Personal Library	Allows users to create and manage their own libraries of items and assemblies.	Allows users to create custom tool sets and save frequently used markups.	Allows users to create and manage their own libraries of items and components.
Autoscale Detection	Supports scaling of drawings to ensure accurate measurements.	Automatically scales drawings based on known dimensions.	Supports scaling of models to ensure accurate measurements.
Export Multiplier	Allows exporting of takeoff data with customizable filters.	Enables exporting of data with customizable options.	Allows exporting of data with customizable filters.
Drawing Over	Supports drawing and markup tools for 2D and 3D models.	Provides robust drawing and markup tools for PDFs.	Provides tools for drawing and marking up 3D models.
Cut:	Supports cutting sections through	Supports cutting sections in PDFs using markup	Supports cutting sections through 3D models to create

Comparison of AI-Enabled Digital Twin Quantity Takeoff Software			
Features	**Autodesk Navisworks**	**Bluebeam Revu**	**Trimble Connect**
	models using section planes and boxes. This allows users to create cross-sectional views to inspect internal details.	tools to create detailed views.	detailed views and inspect internal details.
Smart Fill of Cut Area	Currently, Navisworks does not support filling or capping cut areas directly within the software.	Allows filling of cut areas using markup tools to highlight and annotate specific sections.	Allows filling of cut areas using markup tools to highlight and annotate specific sections.
Smart Copy and Paste	Allows copying and pasting of items and groups within the model. Users can copy properties and viewpoints between models.	Enables copying and pasting of markups and annotations across different documents and pages.	Enables copying and pasting of elements and annotations within the model.
Markup Tools Area Breakdown	Provides markup tools for adding annotations, comments, and measurements to viewpoints and clash results. Markups are automatically saved with the associated viewpoint.	Offers a comprehensive set of markup tools for adding text, shapes, measurements, and annotations to PDFs. Markups can be organized and managed using the Tool Chest.	Provides markup tools for adding annotations, comments, and measurements to 3D models. Markups can be organized and managed within the platform.
Export Grouping:	Allows exporting of grouped data, enabling users to filter and organize exported information.	Allows exporting of grouped markups and annotations, enabling users to filter and organize exported data.	Allows exporting of grouped data, enabling users to filter and organize exported information.
Metric, Imperial, and Metric and Imperial in the Same Project	Supports both metric and imperial units, and allows switching between them within the same project.	Supports both metric and imperial units and allows switching between them within the same project.	Supports both metric and imperial units and allows switching between them within the same project.

Quantity Takeoffs on Large Complex Projects

For large, complex projects, Autodesk Navisworks is generally the best current choice for quantity takeoffs. Each of the three software tools compared here continue to evolve so attention needs to be paid to their evolving capabilities.

Autodesk Navisworks strengths include:

- **Comprehensive Coordination:** Navisworks excels in aggregating data from various sources, making it ideal for large projects that require detailed coordination.
- **Clash Detection:** Its robust clash detection capabilities help identify and resolve conflicts early, which is crucial for complex projects.
- **4D Simulation:** The ability to integrate time-related data for project scheduling (4D simulation) helps in planning and managing large-scale projects.
- **Detailed Quantification:** It provides precise quantity takeoffs directly from 3D models, ensuring accuracy and reducing manual errors.
- **Integration:** Seamlessly integrates with other Autodesk products like Revit, enhancing workflow efficiency.

Consideration must be given to:

- **Complexity:** Navisworks can be complex to use and may require significant training for effective utilization.
- **Cost:** It is generally more expensive than other tools, but the investment is often justified by its advanced features and capabilities.
- **Performance:** Handling large files can sometimes slow down performance, so ensuring adequate hardware resources is important.

Its ability to handle detailed coordination, clash detection, and 4D simulation provides a comprehensive solution that meets the demands of complex construction projects. Autodesk Navisworks incorporates several artificial intelligence (AI) capabilities, particularly through its integration with the broader Autodesk ecosystem. Key AI features include:

- Automated Symbol Detection:
  - Feature: Automatically detects and counts symbols in drawings during quantity takeoffs.
  - Benefit: Saves time and reduces manual effort in identifying and counting elements.
- Predictive Insights:
    - Feature: Analyzes project data to identify and prioritize design, quality, safety, and project control risks.
- Benefit: Helps in making informed decisions earlier in the project lifecycle.
- Clash Detection:
    - Feature: Uses AI to identify and resolve clashes and interferences in the model.
    - Benefit: Enhances project coordination and reduces the risk of costly errors during construction.
- 4D Simulation:
    - Feature: Integrates time-related data for project scheduling and simulation.
    - Benefit: Allows for better planning and visualization of project timelines.

Pros of AI Integration

- Efficiency: Automates repetitive tasks, saving time and reducing manual errors.
- Accuracy: Improves the accuracy of quantity takeoffs and clash detection.
- Predictive Analysis: Provides insights that help with proactive decision-making.

Cons of AI Integration

- Complexity: May require significant training to fully utilize AI features.
- Cost: Higher initial investment due to advanced AI capabilities.
- Data Dependency: The effectiveness of AI features depends on the quality and completeness of the input data.

Overall, the integration of AI in Autodesk Navisworks enhances its capabilities, making it a powerful tool for managing large and complex construction projects.

Summary from a Quantity Takeoff and Estimating Perspective

- **Autodesk Navisworks**: Strong in AI-driven clash detection and automated symbol detection, which are beneficial for accurate and efficient quantity takeoffs. The search features help in quickly locating elements, though it lacks dedicated image search capabilities.
- **Bluebeam Revu**: Excels in visual and text search within PDFs, with robust AI features for document management and automation. These capabilities are particularly useful for extracting quantities from 2D plans and text-based documents.
- **Trimble Connect**: Offers advanced AI for 3D data processing and visualization, which can aid in extracting quantities from 3D models. However, it lacks specific image and text search features that are directly useful for quantity takeoffs.

Each tool has unique strengths in the context of quantity takeoffs and estimating. The best choice depends on whether your focus is on 2D plans, 3D models, or a combination of both, as well as your specific project needs and workflows

For Further Reading – Other Executive Insights

- Adoption of Artificial Intelligence in Quantity Takeoffs in Engineering & Construction Organizations

About the Author

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