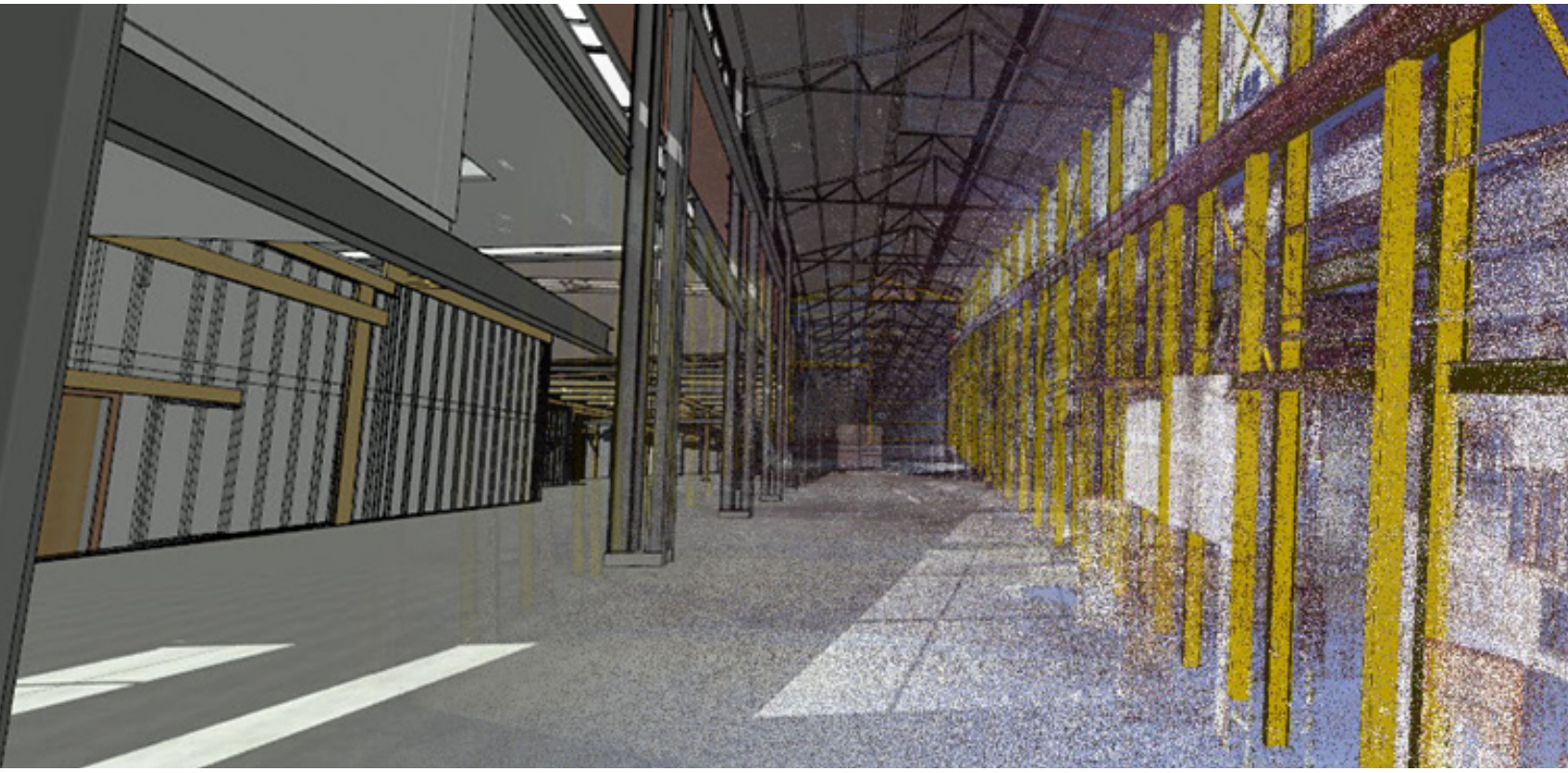
AEC INDUSTRY REPORT

18 PRO TIPS FOR ACHIEVING FAST, ACCURATE STRUCTURAL STEEL AS-BUILTS

Plus Practical Case Studies on How to Take Maximum Advantage of Today's Automated Field Capture and Office "As-Built" Modeling Tools



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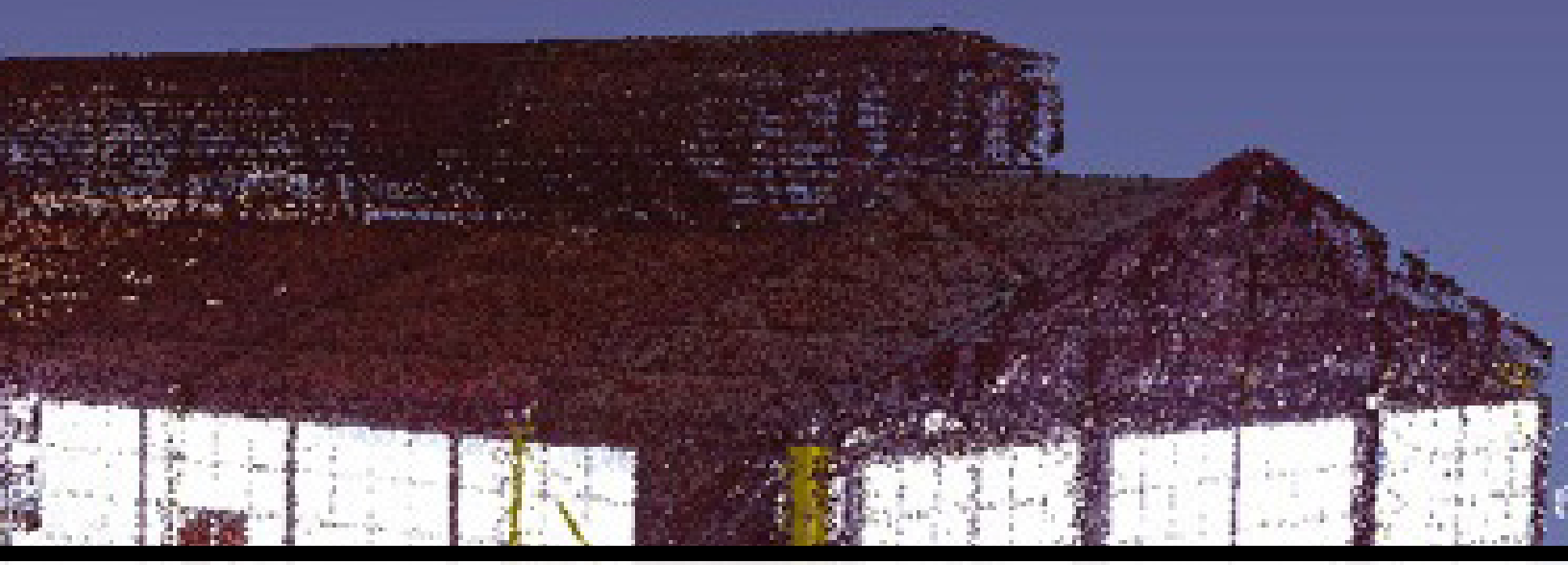
EXECUTIVE SUMMARY

3D laser scanning has rapidly gained popularity for its automatic capture of complete as-is geometry of structures and sites. Users have also increasingly turned to automated software tools that help them more efficiently convert rich laser scan "point clouds" into final and accurate as-built CAD and BIM deliverables. This report features two case studies and the experience of a variety of AEC professionals in deploying these advanced tools for different types of structural as-built projects. The report also provides 18 pro tips for optimizing project efficiency and as-built model accuracy when using these progressive tools.

In our first case study, the organization that made the decision to use laser scanning and automated modeling was the construction services arm of a large property owner. They were new to scanning and point cloud modeling—and chose to self-perform both with support from a CAD services firm. It was a very large project (over 30,000 structural elements) and the process of modeling the structural elements and accurately bringing them into Revit took only a fraction of the time that had been originally expected.

In the second case study, an engineering company retained a service provider to perform laser scanning, point cloud modeling, and BIM deliverables creation to meet their as-built project needs for an old manufacturing plant. The service provider was experienced in using the latest software and hardware technologies, including the use of drones for aerial data capture. This project was smaller in scope, but featured complex geometry and many different types of individual elements. The service provider estimates completing the project roughly 40% faster than it would have taken had they not used automated feature extraction.

In both case studies, the buildings' new owners had little or no existing documentation and required current as-built information to optimally plan and execute modifications to their facilities.



CASE STUDY #1: MASSIVE HISTORICAL FOUNDRY REDEVELOPMENT PROJECT

As-Built Structural Model for 100-Year-Old Foundry Created Dramatically Faster than Expected: the Berkeley Matrix

Fifteen interconnected buildings covering 150,000 square feet comprised a century-old foundry site in Northern California. The plan was to convert the building to creative spaces to support a large and vibrant artist community that is being squeezed by Berkeley's increasingly high commercial rents.

Based in San Francisco, Allen Construction Expediters (ACE) is a management development company with properties throughout the Bay Area. Initial inquiries for capturing the building's detailed structural geometry using traditional methods and creating as-built BIMs were far too costly and time consuming.

On advice from his CAD services partner, Cadworks, Jake Allen, CEO of ACE, investigated the idea of 3D laser scanning. Though previously unaware of laser scanning, it quickly became evident to Allen that this approach was the best way to efficiently gather accurate geometry of each structural element, as well as the complex truss geometry. Subsequent investigations into using local service providers for laser scanning led Allen to a "self-perform" decision. A suitable scanner and point cloud registration software were rented; two days of on-site training were also provided as part of the rental program.

Robert Di Donato is the founder and CEO of Cadworks, Inc., a small CAD services business and ACE partner. Di Donato has over 20 years of experience in CAD, several years' experience with Autodesk® Revit® and building information modeling (BIM), and has numerous laser scanning projects under his belt. However, the Berkeley Matrix project would be the first job where Cadworks used automated point cloud modeling software.

PROJECT DETAILS

- **Size**: 15 different buildings connected with a common roof, covering 150,000 sq.ft.
- **Structural elements**: combination of steel and timber, reflecting numerous modifications over the 100+ year life of the foundry. It's estimated that the building had well over 30,000 structural elements that needed to be captured and modeled.
- **Existing as-built drawings and/or CAD files**: none.
- **Required deliverables**: complete set of as-built drawings derived from a Revit BIM, with a modeled level of detail (LOD) of 300, based on BIM LOD standards. The drawings were for the City of Berkeley, CA, as a basis for discussing future proposed modifications and construction permitting for the historic building.
- **Original estimated schedule:** 120 days (without using automated point cloud processing software) for accurately modeling and locating structural elements and bringing them into Revit.
- **Actual schedule**: 30 days with automated modeling software and two people.

PROJECT CHALLENGES

The immense size and complexity of the interior space proved a major challenge—especially the cavernous centerpiece of the building called the "cathedral" due to the complex internal truss system that supports the high ceiling. The entire building was a complex mixed bag of structural elements and truss systems of different types and sizes that had been installed and many times modified over the years.

Because there were no drawings, each element was a challenge to accurately identify. This meant that each structural element and truss system had to be independently captured and modeled. The large size of the as-built project and final number of scans—more than 900—created additional challenges in planning:

- how to execute efficiently in the field;
- how to manage the large amounts of field-collected and processed data (ultimately almost 4 TB);
- how to store and protect the data;
- and, how to create final as-built deliverables in an efficient way.

Also, this was the construction service company's first project using scanning, so there was a learning curve challenge as well:

"When we first started shopping around, it was amazing what people wanted for producing a set of as-built drawings and how long it was going to take," said Jake Allen, CEO, Allen Construction Expeditors. "It turned out that doing it this way [using laser scanning and automated modeling, plus self-performing] saved us a tremendous amount of time and money... Six months ago, I didn't know about any of this, but now I'm a complete junkie for it."

Registered laser scan point cloud of foundry interior, showing partially modeled steel columns & beams.

PROJECT SOLUTIONS & EXECUTION

Field Scanning & Workflow Metrics

For as-built geometry capture, laser scanning was chosen over manual or total station methods because it offers significantly higher field efficiency as well as better model accuracy and completeness. For this project, a Faro X330 scanner was used with "Quality Setting 4." Higher accuracy and scan density settings were needed because of the relatively long distance of many of the overhead structural elements from the scanner. More dense data also enabled easier, more accurate modeling. Each scan took 8 minutes; still higher quality scans, which were used toward the end of the project, took 11 minutes. Scanner setups were at approximately 40' intervals in the large, open area of the building. Photos were not taken, as this would have required more time per setup and the added value of true color laser scans was not felt to be warranted for this project. Office registration of scans was planned to be done primarily by overlapping scans using a cloud-to-cloud method. No survey control was used and scans were not tied into surveyed points. Field work also included processing each scan in Faro SCENE software as a preparation step for subsequently registering the scans to each other. A 2-person crew took eight weeks to complete data collection and processing.

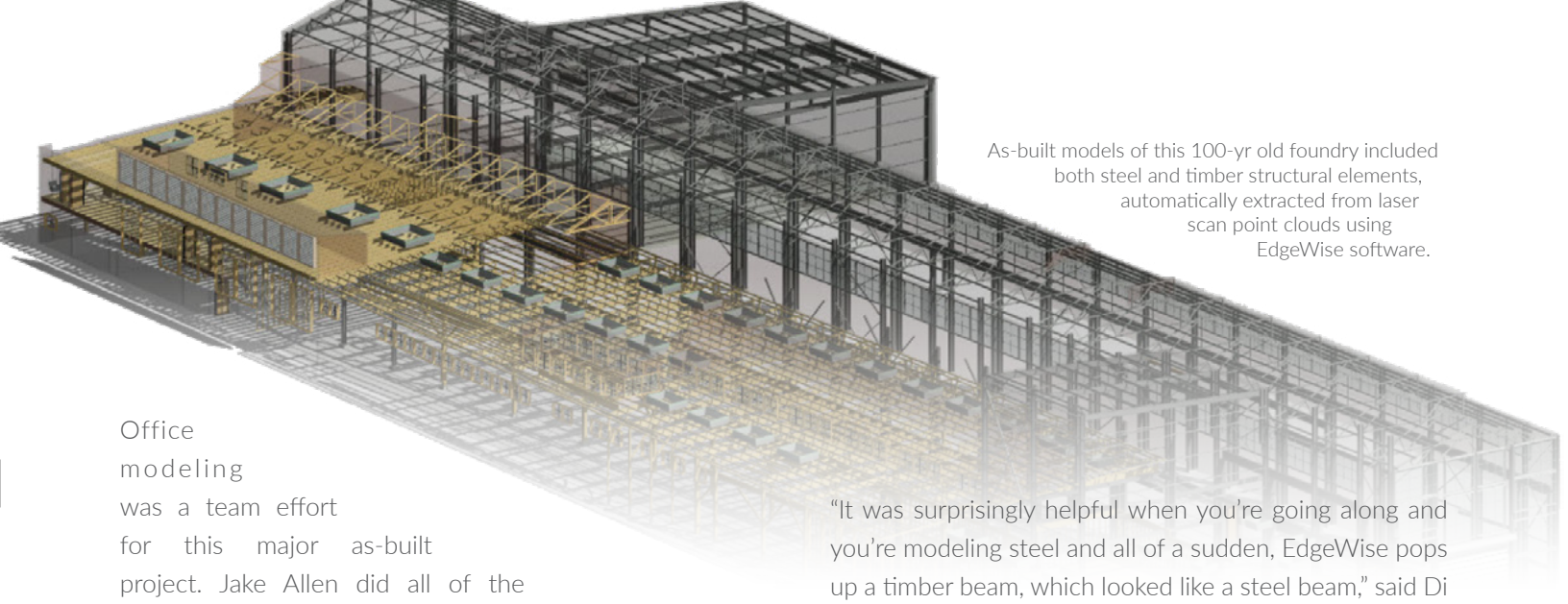
"We've been scanning for a while. This project was so massive, it just didn't make sense to go out and measure things by hand," says Robert Di Donato, CEO, Cadworks.

Office Modeling Workflow & Metrics

From a registration and modeling standpoint, the project was broken down into 15 sections, each representing a unique building under the common roof. Scans within each section were primarily registered in Faro SCENE (90% of total scans) using its cloud-to-cloud registration feature. SCENE's registration report results were stated to be accurate within 3mm. Autodesk Recap Pro software was also used (remaining10% of scans). Registered point clouds were then brought into ClearEdge3D EdgeWise™ software for automated feature extraction and modeling of structural elements, as well as ground surfaces from outside the building.

The building had many unique structural elements—especially wooden elements—which were not fabricated identically to each other. EdgeWise's "Pattern Extraction" tool was able to help automatically extract about 10% of the structural elements with identical geometry. The rest were extracted by segmenting point cloud data for each element and then letting EdgeWise take over to automatically identify it and accurately locate it in space. Modeled structural elements were then brought into Revit for final as-built BIM creation.

"I first tried modeling point clouds directly within Revit for just a small section of one building," said Allen. "After a week, I'd had almost no success and decided to look for a better way. Then I found and tried EdgeWise. When I saw all those automatically modeled EdgeWise elements show up in Revit in exactly the right location, I was literally jumping up and down in the office!"



As-built models of this 100-yr old foundry included both steel and timber structural elements, automatically extracted from laser scan point clouds using EdgeWise software.

Office modeling was a team effort for this major as-built project. Jake Allen did all of the point cloud registration. The total registration labor was 240 man-hours (six weeks), which included some additional time for the learning curve plus extra QA cross-checking via multiple registration methods. Allen also did some extraction using Edgewise with the help of an experienced outside contractor. Due to the extreme variation in element types and geometry, only about 10% of the structural elements were extracted using EdgeWise's "Pattern Extraction" tool. The rest were extracted by "boxing" point cloud areas and letting EdgeWise automatically identify and locate each element. Allen estimated that using EdgeWise was 5-10x more productive than modeling those elements directly within Revit.

Creation of the final as-built deliverables in Revit was done primarily by Cadworks, although Allen also contributed. As overall Project Manager, Allen was keen to familiarize himself with all the office production tools. The modeling process included some manual tracing and modeling of building components that were not able to be automatically modeled with EdgeWise, plus a heavy number of QA/QC checks of Revit objects against point cloud data. At this stage, all modeled building sections were tied together in Revit. Total labor for final Revit modeling was approximately 1,900 man-hours (four people for three months). These hours reflected the historic nature of the 100+ year-old building and the vast array of unique elements that needed special attention. Total file size, including all of the different formats, was approximately 4 TB.

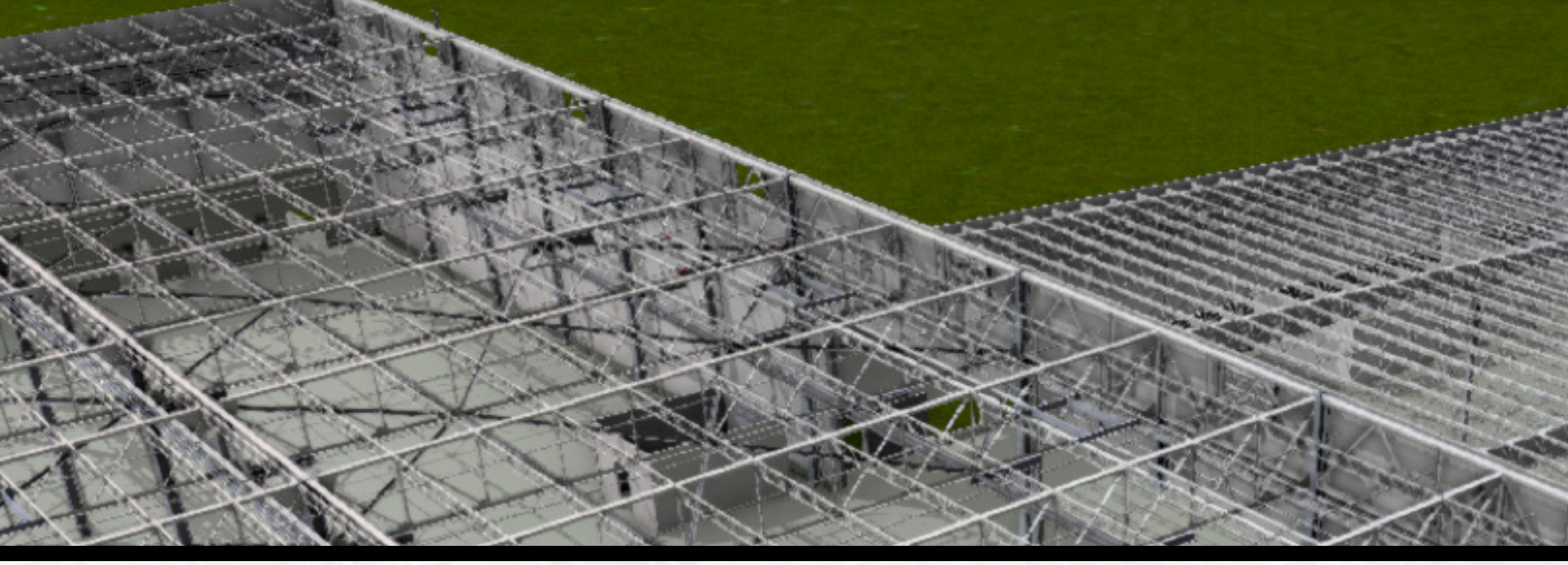
"It was surprisingly helpful when you're going along and you're modeling steel and all of a sudden, EdgeWise pops up a timber beam, which looked like a steel beam," said Di Donato. "So, we were able to identify all of the different types of structural elements throughout the whole project pretty easily. By being able to identify elements and structural parts in EdgeWise, we were able to modify our [Revit] families and size everything correctly. Using EdgeWise to identify elements and then export those into Revit really bumped up our productivity versus trying to bring all of the point cloud data directly into Revit."

Results

The faster-than-anticipated structural modeling translated into coming in well under budget for that portion of the project. In addition to the quick completion, ACE was impressed with the accuracy of the structural as-built. Not only did EdgeWise accurately differentiate between two types of structural materials, it modeled them in their correct sizes, orientations, and locations. This was impressive given the fact that so many of the truss members were connected to each other at a variety of odd angles.

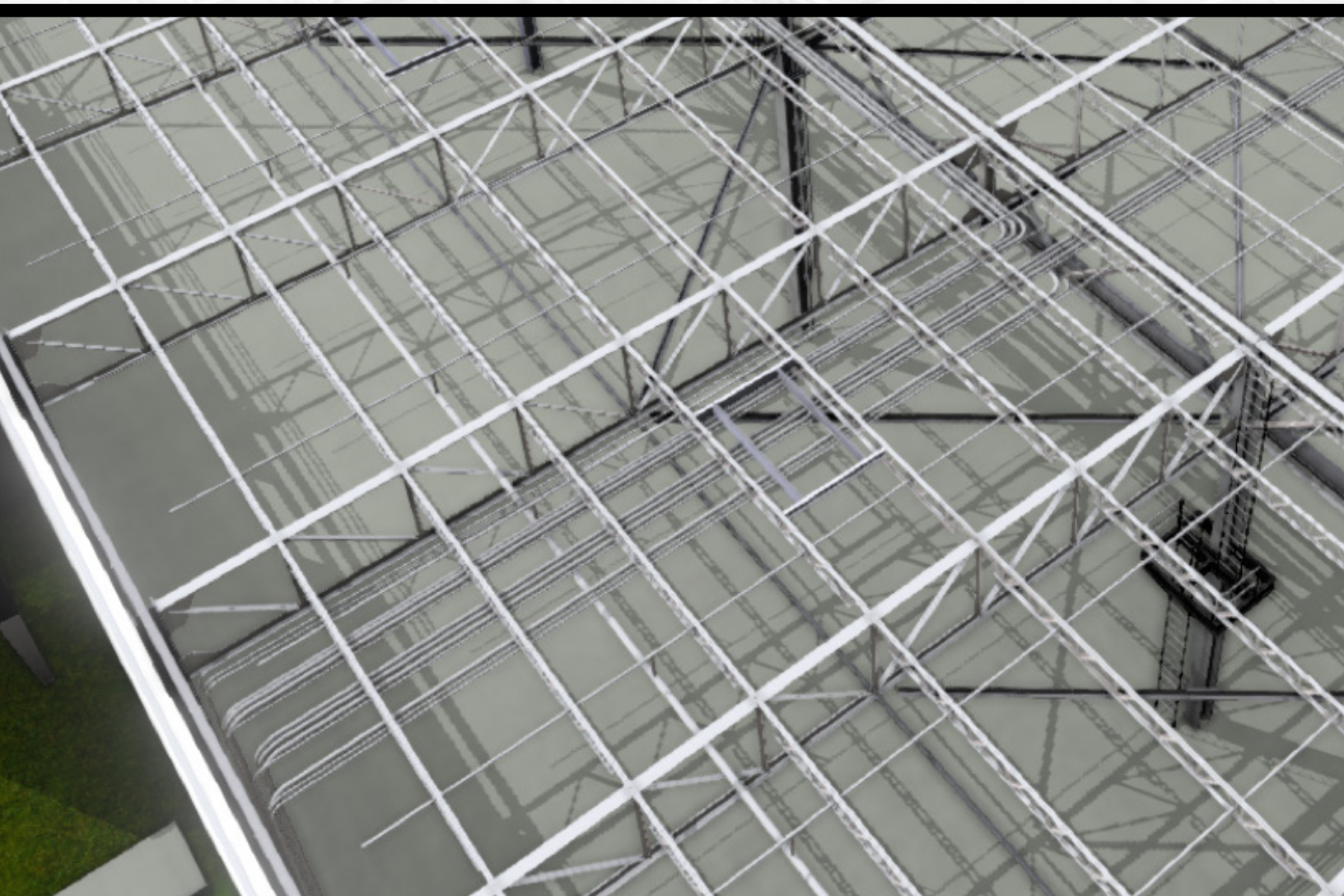
The other big surprise was that the speed of modeling was many times faster than modeling point clouds directly in Revit.

"It was unbelievable how much faster it was to do this with EdgeWise and how accurately it brought everything into the Revit models to create the final product," concludes Allen. "We couldn't have gotten to this [result] with just Revit alone. EdgeWise saved us hundreds of hours of modeling time."



CASE STUDY #2:
MANUFACTURING PLANT CONVERSION

HALE TiP creates the structure, architecture, and MEP as-built for a manufacturing plant conversion on an ultra-demanding schedule.



The owner of a large, former steel fabrication plant in Michigan was converting the facility to handle the manufacture of aircraft engines. The 120,000-sq. ft. building had been used over time by different owners for steel fabrication, warehousing, and automotive-related manufacturing.

The overall conversion would involve changes to the electrical, water, and HVAC systems, compelling the owner to request a complete 3D Revit as-built model including structural, architectural, and MEP elements for the interior and exterior of the building. Particularly critical was an accurate understanding of structural elements and truss systems so they could be properly reinforced for the new industrial rail and cranes that were to be installed.

The engineering firm tasked with design was already keen to use laser scanning for the project and they had another important need: rapid turnaround. "Can you be here next week to scan?" was the first question to candidate laser scanning and BIM modeling service providers. The second question was, "Can you deliver an accurate as-built model within two weeks after you scan?"

With their experienced team—and knowing the efficiencies they would achieve using 3D laser scanning in the field combined with modeling using automated feature extraction back at the office—HALE TiP, a Rochester, NY-based scanning, BIM, and VDC services company, was able to confidently answer "yes" to both questions.

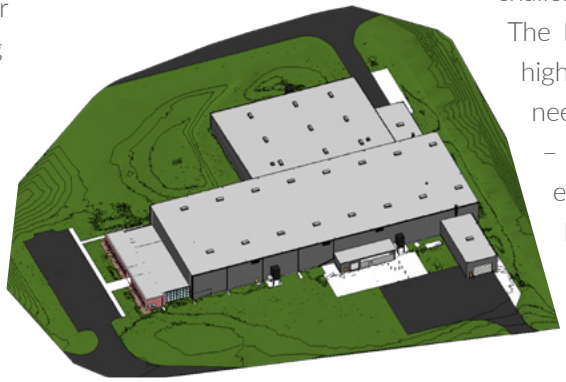
"Traditional [field & office as-built] methods would have taken a good amount of time to lay things out," says Greg Hale, CTO, HALE TiP. "Often times that would be done fairly inaccurately, fairly rough, and they would kind of figure things out as they go along in the field and, as we all know, those all end up in change orders."

PROJECT DETAILS

- **Size**: 120,000 sq. ft.; 50' high ceilings.
- **Structural & piping elements**: 6,000 structural elements plus 600 pipes needed to be captured and modeled. There was a wide variety of different steel elements and multiple truss systems. Truss work in high bays was complex. Some steel elements had been beefed up or changed out over the years as structural improvements for prior crane systems.
- **Existing as-built drawings and/or CAD files**: none.
- **Required deliverables**: Revit as-built model including structural, architectural, and MEP data. Equipment locations on the roof top were also needed. For the client's design needs, each element had to be accurately identified and located, but elements were allowed to be modeled as orthogonal, plumb, and straight, even if they weren't perfectly so. Site topography was also required.
- **Original estimated schedule**: project was planned for scanning to start within one week of signed contract and the model to be delivered within 3 weeks of the completion of scanning and other geometric data capture. The original estimate for structural and pipe modeling without ClearEdge3D automation was 220 man-hours.
- **Actual Schedule**: delivered two weeks after scanning with 140 office man-hours (a savings of 80 man-hours).

PROJECT CHALLENGES

From an as-built modeling perspective, the project was challenging in many ways. The building was large with high ceilings, and the client needed all visible features – walls, windows, pipes, electrical conduits, HVAC ducts, and complex overhead trusses – located and identified. The lack of existing drawings meant HALE TiP couldn't make any assumptions about the features that would be found. In fact, the individual elements and truss work were not necessarily the same from one bay to the next in the facility, so you couldn't just "copy-and-paste" geometry—each structural element and each truss pattern had to be accurately captured and modeled. Capping it off was the deadline that required every phase of the as-built modeling process to be carried out quickly, including a



Perspective view of as-built modeled building shell and site derived from drone images and point cloud processing (manufacturing plant conversion project).

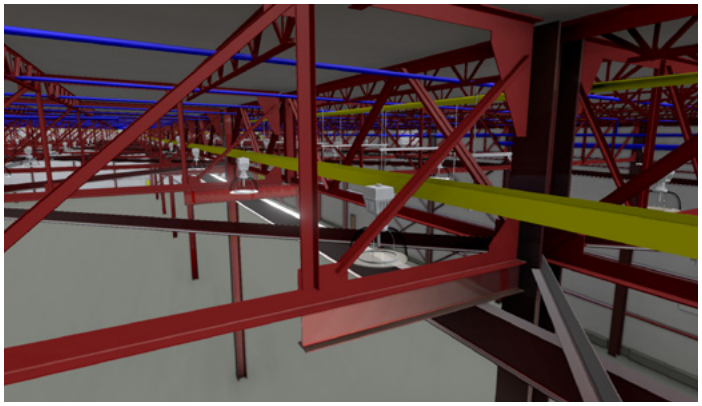
partial model delivery within one week of scanning that the client needed to start critical-path design work. Finally, safety concerns about putting staff and scanning equipment on the roof forced HALE TiP to consider alternate methods for capturing roof geometry.

"Even with a smaller scale project like this," says Hale, "it [using EdgeWise for automated modeling of laser scans] provided a substantial difference in fee."

PROJECT SOLUTIONS & EXECUTION

Field Scanning Workflow & Metrics

To meet schedule demands and as-built accuracy requirements, a decision was made to use 3D laser scanning for capturing the building interior and to use a photogrammetric drone to safely capture the roof exterior. The alternative considered for interior capture would have been using traditional manual or total station methods, but those methods would not have been efficient, accurate, or complete enough. HALE TiP already had extensive experience using laser scanning for similar projects, so there was no hesitation around using it for this one.



Modeled as-built steel and truss systems for planning manufacturing plant conversion

To further reduce field time and minimize cost, HALE TiP decided to use two technicians, each equipped with a FARO Focus3D X330 laser scanner. On previous jobs, the firm discovered that two operators with two scanners captured data 2.5 times faster than one person with one scanner if they worked together, sharing survey control targets and leapfrogging through the space.

A surveyor was present to coordinate the overall building site and provided HALE TiP with reference site coordinates. This enabled Hale TiP to accurately tie both interior and exterior point clouds into site coordinates. These were the same coordinates used by project engineers and architects, thus providing additional value for the project.

The 220 scans taken included scans at doorways to the outside of the building, which enabled tying interior scans to site coordinates. No photos were taken with the scanner, as they were not needed to create the required deliverables; taking photos for the purpose of overlaying true colors onto point clouds would have added extra time in the field. To capture the roof and site geometry, a DJI Inspire 1 drone was used. Total field time for all interior and exterior geometry capture was 1.5 days with a staff of two.

Each Faro scanner was used with a "quality setting" that corresponded to about 6 minutes per scan. Using a higher quality setting would have provided more dense scan data for each element and less scan noise. Though this would help when modeling, it takes considerably more time per scan. For this project, the team used faster scans with lower scan density/higher noise (i.e. a lower quality setting), but with more scanner positions. More scanner perspectives provides better scan coverage of more sides of objects, which also benefits office modeling of point clouds.

Office Modeling Workflow & Metrics

Another insight HALE TiP has discovered is that project quality is enhanced when the scanning crew is also the modeling crew. So, all office processing of laser scans and drone images was done by the same technical staff who collected the data in the field. Faro SCENE software was used for point cloud registration, taking advantage of the spherical targets that were placed and scanned as part of each area scan. Scan registration required 14 man-hours for one person.

Registered scans were then brought into EdgeWise software for automated processing of point clouds into modeled objects. Hale TiP is a long-time user of EdgeWise software and had already leveraged it on dozens of projects. A batch overnight process (~8 hours) was used to automatically model piping and the ground with EdgeWise with 95% of the pipes successfully extracted.

For structural elements, about 10-15% of the total number were extracted using the EdgeWise automated "Pattern Extraction" tool. Another 65% were extracted using EdgeWise by quickly "boxing" a section of the point cloud for each element and letting EdgeWise automatically identify and locate it.

All extracted elements were then brought into Revit for the creation of the final as-built model. This included a workflow that enabled processing the EdgeWise model elements via the Revit Project environment into Revit Families. Within the Revit Project environment, steel pieces extracted by EdgeWise were grouped, and then extracted out as a group into a native Revit Family. Some additional variations were made based on additional extractions of steel. This took two experienced modelers about two calendar weeks to accomplish.

Total modeling labor was 140 man-hours. This was comprised of 28 man-hours working in EdgeWise, 100 man-hours working in Revit to create the final as-built model, and 12 man-hours of additional modeling coordination and QC. Using EdgeWise netted a modeling labor savings of 80 man-hours (against an estimated total of 220 man-hours if they had done all the point cloud modeling directly in Revit).

Another benefit of using EdgeWise instead of using Revit alone was better accuracy of the final model based on EdgeWise' precise modeling algorithms and robust QA/QC tools for piping and structure. In contrast, piece-by-piece manual modeling directly within Revit often includes an approximation for certain pieces.

Hale also utilized ClearEdge3D's Verity™ software to analyze the deflection of the beams after modeling. EdgeWise models the straight beam best fit to the point cloud, but in some cases the beams in this existing facility were deflected, causing potential problems for new systems and structures being installed. Verity allows a fast, automated check to see if any of the beams exceed the design requirements and thus might require remediation.

Pix4D software was used to convert drone photogrammetric images of the building roof and exterior ground area into point clouds. Drone-based point clouds were then tied to the interior point cloud in Faro SCENE.

For QC/QA purposes, two separate methods were used for this additional aerial point cloud registration: cloud-to-cloud registration and surveyed points registration. There was good agreement between both approaches. Total processing for aerial data was 3 man-hours.

EdgeWise (via LandXML and Revit's Site Designer" tool) was also used to extract ground. This was valuable for keeping the building model in context of the surrounding outside landscape and hardscape, should modifications be considered for those areas.

Results

Just two weeks after capturing the scans in Michigan, HALE TiP delivered the as-built model to the engineering client. The model contained some surprises, however. EdgeWise revealed that not all of the structural steel beams in overhead truss network were identical, despite appearing so from below. The software found several beams were thicker than others, indicating the trusses had been reinforced at some point in the past. This information proved valuable to the client as they decided where and how to install the heavy cranes for the aircraft engine assembly line.

"Extraction software is more accurate than humans because we approximate too much," says Hale. "Modeling existing conditions can be very challenging. EdgeWise doubles our modeling speed and, at the same time, allows us to mitigate risks by providing accurate representations."

As-built modeled elements shown over point cloud for manufacturing plant conversion.

18 PRO TIPS FOR ACHIEVING FAST, ACCURATE STRUCTURAL STEEL AS-BUILTS

"We achieved 2.5X field efficiency by using two scanners and 2 field staff. It's noticeably better than simply 2X because staff can help each other use a leap frog approach for scanning and help with QC, etc."

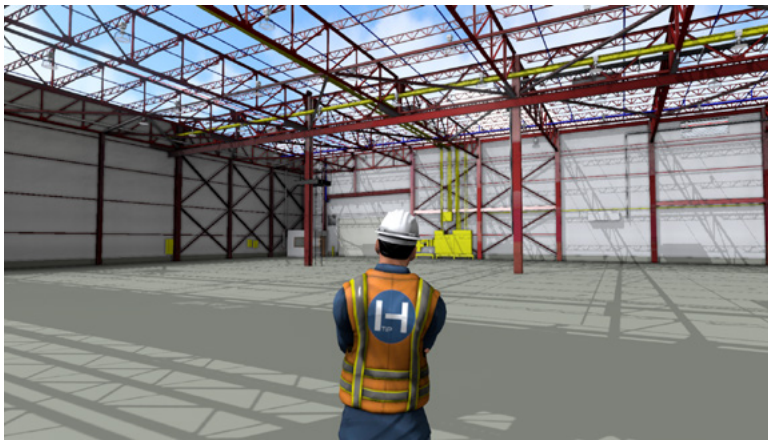
- Greg Hale, CTO, Hale TiP

PROJECT MANAGEMENT TIPS

1. **Establish a Data Management Plan**: For large, complex projects, know beforehand (a) how you are going to process the data, (b) where the data is going to reside, (c) who is going to have authorized access to the data, and (d) how all data will be tied together to complete the project.
2. **Use One Team for Scanning AND Modeling**: When possible, use the same field staff to also process scan and photogrammetric data in the office. They will be more familiar with the project, which leads to higher office efficiency and reduces the risk of getting something wrong or missing something.
3. **Understand the Use Case**: Make sure you understand exactly what the as-builts will be used for. Is it for general planning purposes? Is it for exact structural and/or clash analysis? Do the drawings need to show everything square and plumb or do they need to show deflection and out-of-plum situations? The answers can have a significant impact on the level of accuracy needed and on modeling time and methodology.

FIELD DATA CAPTURE TIPS

4. **Use Multiple Scanners for Maximum Efficiency**: Using two scanners and two field staff for one day is more efficient than using one scanner with one person for two (2) days.
5. **Spheres and Targets are your Friend**: Using spheres/scan targets for registration enables valuable checking and QC.
6. **Control Prevents Chaos!** Tying into survey control is good practice, when feasible (with a nod to Maxwell Smart).
7. **Scan Density Matters:** Scanning at higher density, higher accuracy, and lower scan noise settings makes modeling easier in the office; likewise, scanning from more perspectives – even if it's done at lower data quality settings with noisier scan data – also makes modeling easier in the office, as it captures more sides of objects.



Rendering and VR software can provide additional project QA for complex interior as-built projects.

8. **Add a Drone to your Reality Capture Quiver:** Photogrammetric drones can be a viable option for capturing roof or other geometry that may be difficult or unsafe to access with a laser scanner. Overlapping drone images can be stitched together and converted to point clouds and then combined with interior building scans.

OFFICE (MODELING & DELIVERABLE CREATION) TIPS

9. **Older Structure is Often Atypical**: Don't assume that all structural bays are "typical". Especially for older buildings, individual elements may have been beefed up or modified; truss systems may have been designed and built differently. Scan and model elements - don't rely on the naked eye!

10. **Make Trusses a Family Affair**: Create In-Place Truss Families in Revit and convert them to Loadable Families.

11. **EdgeWise Ground Extraction Gives Important Context**: Auto-extracting ground in EdgeWise (via LandXML and Revit's Site Designer tool) is valuable for keeping the building model in context of the surrounding outside landscape and hardscape, should modifications be considered for those areas.

12. **Use QA Tools to Spot and Correct False Positives**: Laser scanning captures everything that a scanner can reach and detect a laser return. As a result, auto-extraction of point cloud data can periodically create "false positives", i.e. something is extracted from scan points that's not really a true pipe, duct, etc. However, EdgeWise has powerful QC/QA tools that aid in efficiently sorting these out.

13. **Use Verity as a Model Checker**: Although Verity software is primarily intended for construction QA, it can also be used to validate the quality of the as-built model and to make sure it accurately conforms to the point cloud. This is particularly valuable as a QA check on inexperienced modelers or outsourced modeling jobs. In addition, Verity can provide better quantitative understanding of real world variances, such as beam deflection.

14. **EdgeWise for Repetitive Elements, Revit for One-Offs**: To best handle out-of-plane walls, use EdgeWise auto-extraction tools for repetitive applications; for one-off applications, manual tools in AutoCAD or Revit may be sufficient. It's possible to create "heat map" type deliverables that show variations in wall surface flatness; however, be careful about "over specifying" accuracy of modeled walls, as construction tolerances, for example for dry wall surfaces, are bigger than typical modeling specs.

15. **Don't Forget to Add Non-Standard Specs**: Although EdgeWise extracts to industry standard steel and piping geometries from a comprehensive database, non-standard or non-spec elements can be added to the EdgeWise database so that these geometries can also be automatically extracted.

16. **Don't Just Rely on Auto-Extraction**: Extraction tolerances can be set in EdgeWise to most efficiently process point clouds to the level of accuracy needed for deliverables. However, sometimes user judgment is called for

"In the beginning, we were using Dropbox to place the data. Someone who was not involved with the project had access to Dropbox and deleted project data files. It was a valuable lesson learned."

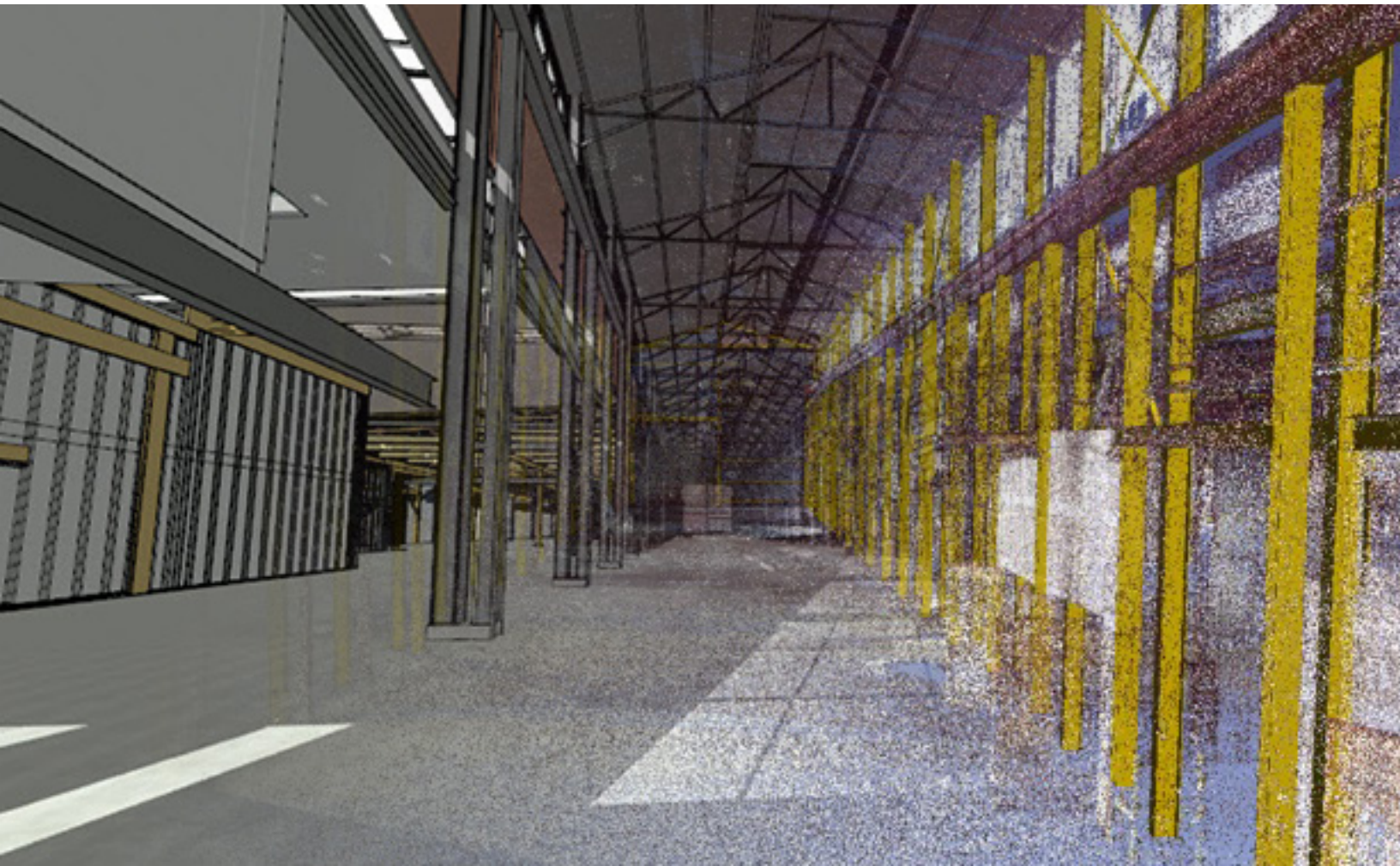
- Jake Allen, CEO, Allen Construction Services

"At every facility that's out there, it's not plumb, and it's not straight, and it's not flat. The QA tools in extraction software are very helpful in understanding their true conditions."

- Greg Hale, CTO, HaleTiP

to make more appropriate modeling decisions. For example, EdgeWise may capture the lean of a column which is only an eighth of an inch out of vertical as indicated by the scan data, but a user may prefer to represent the column as being perfectly vertical, knowing that it will make subsequent renovation design work easier in Revit. Judgment calls can often be part of the overall process.

17. **Try New VR Software like Fuzor to Render Real-Time**: In addition to standard QA/QC tools, another valuable project QA/QC methodology is the use of Fuzor software. This software provides real-time rendering – typically on a second monitor – as modeling is proceeding. For a still higher level of QA/QC, users can use a VR headset with Fuzor to literally "re-walk" inside a site as it's being modeled. This enables a user to check to see if anything is missing based on the user's recollection of being at the site. Further, designers can also design within the enhanced realism of a VR environment and save designs out to Revit. Point clouds and models can both be used in this way.
18. **Use Industry Standards**: Useful industry standards for best practices at applying laser scanning and modeling methods to these types of projects are (a) USIBD (US Institute of Building Documentation) standards for laser scanning and point cloud modeling guidance, and (b) BIM LOD (Level of Detail) standards for general modeling detail guidance.



STRUCTURAL STEEL AS-BUILT TIPS AT-A-GLANCE

18 PRO TIPS FOR ACHIEVING FAST, ACCURATE STRUCTURAL STEEL AS-BUILT MODELS

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PROJECT MANAGEMENT TIPS

1. **Establish a Data Management Plan**: For large, complex projects, know beforehand (a) how you are going to process the data, (b) where the data is going to reside, (c) who is going to have authorized access to the data, and (d) how all data will be tied together to complete the project.
2. **Use One Team for Scanning AND Modeling**: When possible, use the same field staff to also process scan and photogrammetric data in the office. They will be more familiar with the project, which leads to higher office efficiency and reduces the risk of getting something wrong or missing something.
3. **Understand the Use Case**: Make sure you understand exactly what the as-builts will be used for. Is it for general planning purposes? Is it for exact structural and/or clash analysis? Do the drawings need to show everything square and plumb or do they need to show deflection and out-of-plum situations? The answers can have a significant impact on the level of accuracy needed and on modeling time and methodology.

FIELD DATA CAPTURE TIPS

4. **Use Multiple Scanners for Maximum Efficiency**: Using two scanners and two field staff for one day is more efficient than using one scanner with one person for two (2) days.
5. **Spheres and Targets are your Friend**: Using spheres/scan targets for registration enables valuable checking and QC.
6. **Control Prevents Chaos!** Tying into survey control is good practice, when feasible (with a nod to Maxwell Smart).
7. **Scan Density Matters:** Scanning at higher density, higher accuracy, and lower scan noise settings makes modeling easier in the office; likewise, scanning from more perspectives – even if it's done at lower data quality settings with noisier scan data – also makes modeling easier in the office, as it captures more sides of objects.
8. **Add a Drone to your Reality Capture Quiver:** Photogrammetric drones can be a viable option for capturing roof or other geometry that may be difficult or unsafe to access with a laser scanner. Overlapping drone images can be stitched together and converted to point clouds and then combined with interior building scans.

OFFICE (MODELING & DELIVERABLE CREATION) TIPS

9. **Older Structure is Often Atypical**: Don't assume that all structural bays are "typical". Especially for older buildings, individual elements may have been beefed up or modified; truss systems may have been designed and built differently. Scan and model elements - don't rely on the naked eye!
10. **Make Trusses a Family Affair**: Create In-Place Truss Families in Revit and convert them to Loadable Families.
11. **EdgeWise Ground Extraction Gives Important Context**: Auto-extracting ground in EdgeWise (via LandXML and Revit's Site Designer tool) is valuable for keeping the building model in context of the surrounding outside landscape and hardscape, should modifications be considered for those areas.
12. **Use QA Tools to Spot and Correct False Positives**: Laser scanning captures everything that a scanner can reach and detect a laser return. As a result, auto-extraction of point cloud data can periodically create "false positives", i.e. something is extracted from scan points that's not really a true pipe, duct, etc. However, EdgeWise has powerful QC/QA tools that aid in efficiently sorting these out.
13. **Use Verity as a Model Checker**: Although Verity software is primarily intended for construction QA, it can also be used to validate the quality of the as-built model and to make sure it accurately conforms to the point cloud. This is particularly valuable as a QA check on inexperienced modelers or outsourced modeling jobs. In addition, Verity can provide better quantitative understanding of real world variances, such as beam deflection.
14. **EdgeWise for Repetitive Elements, Revit for One-Offs**: To best handle out-of-plane walls, use EdgeWise auto-extraction tools for repetitive applications; for one-off applications, manual tools in AutoCAD or Revit may be sufficient. It's possible to create "heat map" type deliverables that show variations in wall surface flatness; however, be careful about "over specifying" accuracy of modeled walls, as construction tolerances, for example for dry wall surfaces, are bigger than typical modeling specs.
15. **Don't Forget to Add Non-Standard Specs**: Although EdgeWise extracts to industry standard steel and piping geometries from a comprehensive database, non-standard or non-spec elements can be added to the EdgeWise database so that these geometries can also be automatically extracted.
16. **Don't Just Rely on Auto-Extraction**: Extraction tolerances can be set in EdgeWise to most efficiently process point clouds to the level of accuracy needed for deliverables. However, sometimes user judgment is called for to make more appropriate modeling decisions. For example, EdgeWise may capture the lean of a column which is only an eighth of an inch out of vertical as indicated by the scan data, but a user may prefer to represent the column as being perfectly vertical, knowing that it will make subsequent renovation design work easier in Revit. Judgment calls can often be part of the overall process.
17. **Try New VR Software like Fuzor to Render Real-Time**: In addition to standard QA/QC tools, another valuable project QA/QC methodology is the use of Fuzor software. This software provides real-time rendering – typically on a second monitor – as modeling is proceeding. For a still higher level of QA/QC, users can use a VR headset with Fuzor to literally "re-walk" inside a site as it's being modeled. This enables a user to check to see if anything is missing based on the user's recollection of being at the site. Further, designers can also design within the enhanced realism of a VR environment and save designs out to Revit. Point clouds and models can both be used in this way.
18. **Use Industry Standards**: Useful industry standards for best practices at applying laser scanning and modeling methods to these types of projects are (a) USIBD (US Institute of Building Documentation) standards for laser scanning and point cloud modeling guidance, and (b) BIM LOD (Level of Detail) standards for general modeling detail guidance.

If you are interested learning more about EdgeWise & Verity or would like to apply for a trial license, please contact sales@clearedge3d.com.

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