BEST PRACTICES FOR BIM IN CONSTRUCTION

OFFICE-TO-FIELD AND BACK

HEXAGON

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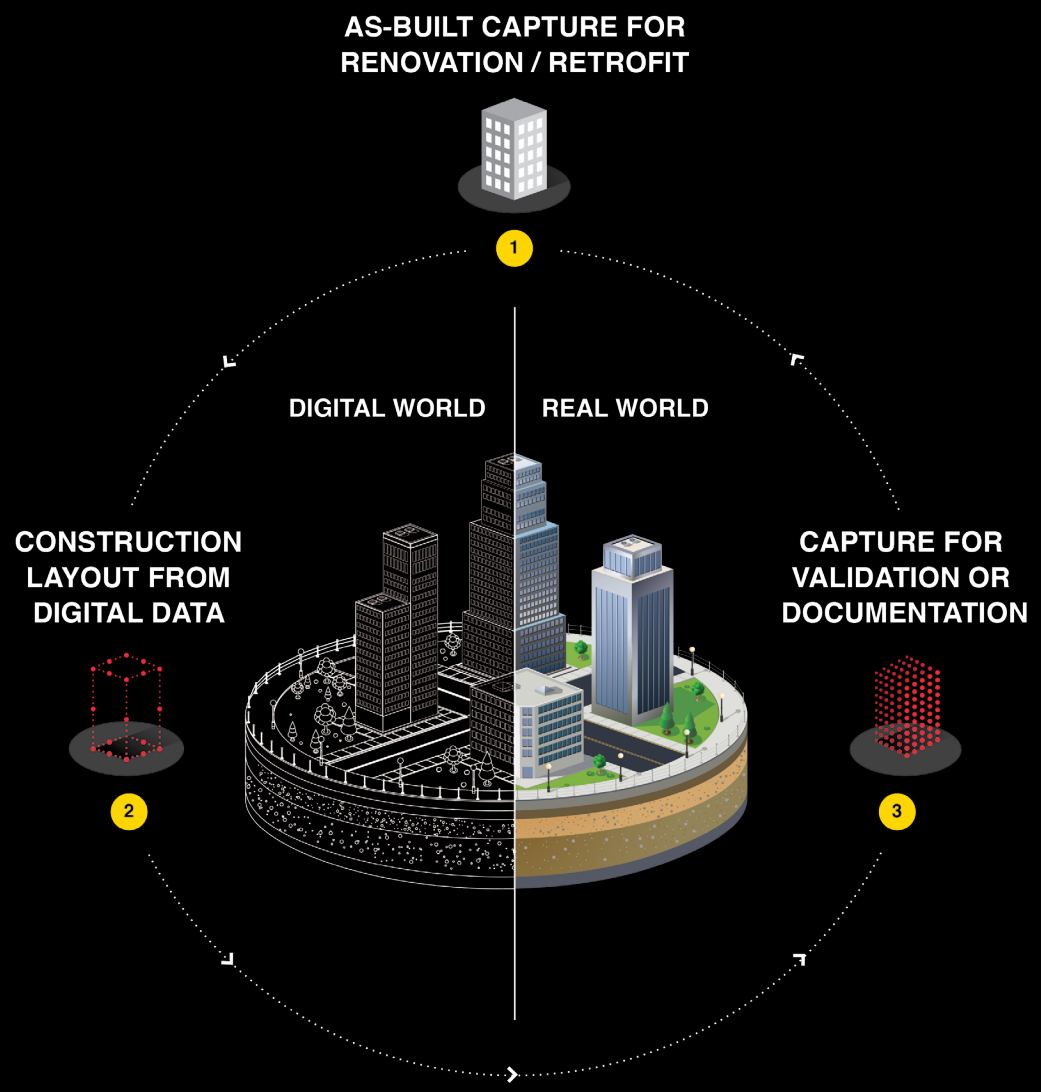
INTRODUCTION:
A SMARTER APPROACH TO BIM

Most construction firms are well aware of the benefits of using building information modeling, or BIM, to identify problems before they happen and facilitate more complete building systems integration. However, gaps between the idealized digital world in the deign office and the physical real-world nature of the field often prevent projects from achieving their full potential. Rich digital models are often converted to 2D paper drawings for use in the field, where guesswork and manual layout processes can cause errors that are difficult to detect until later in the construction process. Additionally, on renovation or retrofit projects, many models are created from outdated and inaccurate as-built drawings, leading to problems in the field during construction, which drive up project costs, increase risks and even derail entire projects.

There is a better way.



In an ideal BIM workflow, the project team captures reality and informs the 3D model with highly accurate discrete measurement points and as-built point clouds. New design models are then created around the accurate as-built data, and construction layout points are added to the model. These points are then replicated on the jobsite using tools such as total stations to bring BIM to reality. During construction, progress is measured, quality is checked, and information is captured with high-accuracy total stations and high definition scanners. The accurate discrete measurement points and point clouds are compared against the as-designed model to immediately identify deviations and head off expensive downstream coordination issues in the field.

The result is a lifecycle process that brings reality into BIM and BIM into reality for a holistic building construction approach. Through innovative hardware and software integrations, today's construction professionals have faster and easier access to high-accuracy data throughout the entire construction process, making it possible to minimize rework and achieve new levels of efficiency, safety, predictability, and profitability.

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“With the Leica RTC360 laser scanner, we’re easily achieving a 60 percent time savings on verifying existing conditions and producing as-builts. And we’re able to deliver information the architects and engineers can work from the very next day, which gives them a huge advantage.”

Brandon French
Senior Reality Capture Technician, WD Partners

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Renovation and retrofit projects present a unique set of challenges. Drawings of the existing buildings are often extremely outdated or do not exist. Simply getting to the point where the existing structure is documented is expensive and time-consuming. Being able to accurately capture existing conditions and easily feed that information into the model is imperative to keeping projects on time and on budget.

A simple way to achieve this goal is to capture point clouds using a reality capture solution that integrates seamlessly with your existing CAD/BIM software to provide a streamlined workflow.

THE VALUE OF ACCURATE DATA CAPTURE BEFORE DESIGN & CONSTRUCTION

Informing the Model with Point Clouds

For larger projects and more complex spaces, laser scanning is increasingly used to capture reality in a set of data known as point clouds. The laser scanner captures millions of discrete points along with imagery and creates a virtual representation of the site in its current form. This data then can be brought into CAD or BIM packages and used to develop extremely accurate existing condition drawings and models.

When using a high-quality laser scanner, the point cloud data is so complete that it provides the team with details all the way down to the bolt patterns on steel pipe fittings. Many software packages have built-in libraries where actual sizes of steel and/or pipes can be identified and modeled directly from the point cloud.

Libraries of shapes or grouped models can be made and used throughout the site. In a renovation context, the point cloud can be used to create paths with correct clearances to bring mechanical equipment and prefabricated elements into the site and building. The point cloud can also be used to create paths with the correct clearances to remove large equipment from the site once construction is complete.

On a typical construction project, rework accounts for 12 to 15 percent of the cost of construction. With laser scanning, the ability to catch conflicts before they happen can reduce rework to 1 to 3 percent or less. This reduction translates into hundreds of thousands of dollars in savings on change orders, not to mention the advantage of keeping the project on schedule and providing valuable information for all stakeholders.

Simple Yet Powerful Workflows

In the past, the complexity of laser scanning was considered a significant barrier to construction teams that wanted to inform their models with 3D point clouds. However, recent advances in hardware and software along with new hardware/software integrations have made laser scanning easy to incorporate into construction projects with confidence.

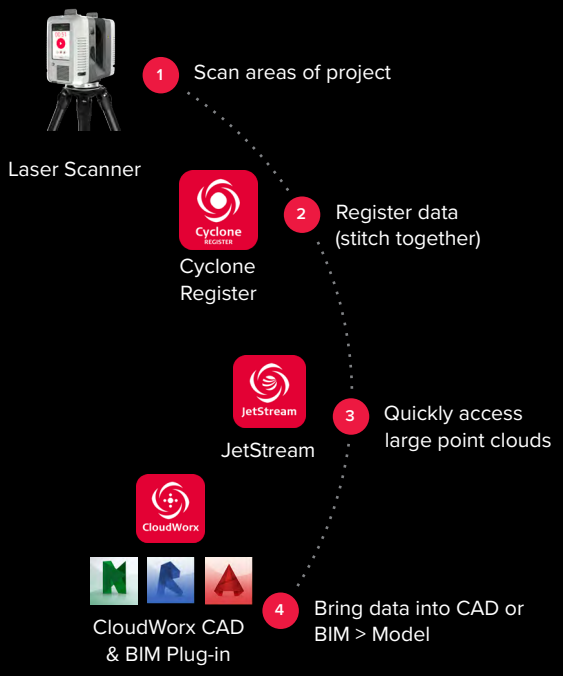
New innovations make working with point clouds fast and easy. For example, the Leica RTC360 enables you to capture complete scans and High-Dynamic Range (HDR) imagery in less than two minutes. Leica Cyclone FIELD 360 mobile-device app uses edge computing to automatically register your scans in real time, and Leica Cyclone REGISTER 360 office software integrates your 3D model seamlessly into your workflow.

Point clouds are then available for use in CAD or BIM software using the fast, high-performance Leica JetStream back-end database and Leica CloudWorx plug-ins that provide point cloud management tools, such as advanced point cloud clip boxes, point cloud clips for Autodesk Revit family editor, point cloud color options, analysis and model creation tools.

SIMPLE YET POWERFUL WORKFLOW

BENEFITS:

- Comprehensive yet intuitive point cloud management
- CAD & BIM plug-ins with production point cloud tools
- Ultra-fast point cloud server - fully interoperable



Point clouds can be used to create simple heat maps of floor flatness or to conduct best-fit modeling and deviation detection on piping. For easy sharing with all stakeholders, point clouds and COE models can be published to the Leica TruView Server with Leica Cyclone Publisher and shared on any device or browser through Leica TruView Global.

Once models are informed with accurate 3D data, laser scanning can continue to add value by capturing construction milestones and providing quality assurance as the project progresses.

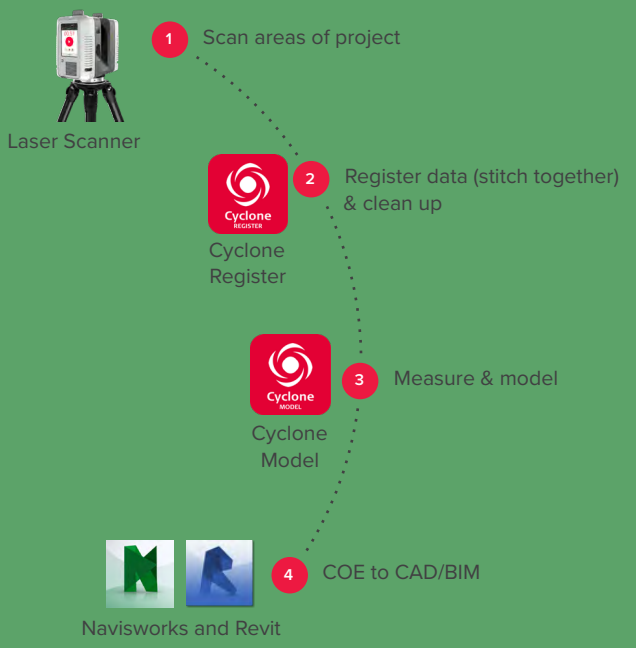
An intuitive and accessible option for those new to laser scanning uses scan data from the Leica BLK360, a compact laser scanner that provides clean, accurate data capture with easy one-button-push operation, imported in its native format directly into Autodesk® ReCap™ for use in a CAD or BIM environment with common software such as Autodesk® Revit®, Navisworks®, or AutoCAD®. This approach can facilitate modeling and provide easy data access across project teams, regardless of CAD or BIM skill level.

Whether construction companies hire a service provider to do the scanning or self-perform scanning, there are countless benefits to including the technology on a construction project. And with the seamless workflows available in the most commonly used software tools, incorporating 3D laser scanning data into the construction process is so simple that it's difficult to justify not doing it.

LEICA SCAN TO MODEL

BENEFITS:

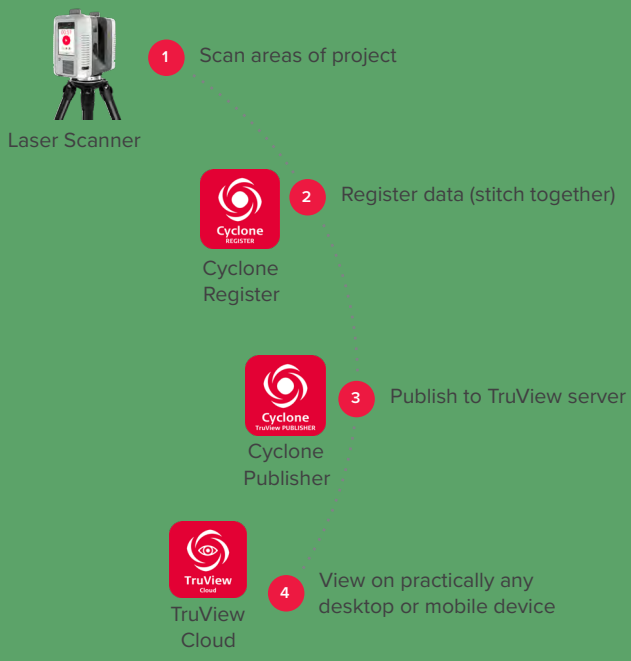
- The only complete 3D verification
- View, register, and model in same environment
- Robust steel, pipe and surface fitters
- Import COE models into TruView Global with point clouds



UBIQUITOUS POINT CLOUD SHARING

BENEFITS:

- View and measure point clouds
- Conduct mobile visual deviation detection
- Conduct mobile virtual safety inspections
- View on practically any device
- No CAD, BIM or point cloud expertise needed



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Once a project is working with highly accurate models in the office, that's a good start for BIM. In many cases, however, the model data isn't being used directly in the field. At best, this information gap drives up project risks; at worst, it results in errors and delays that can derail the entire construction schedule and budget and potentially lead to litigation.

Fortunately, these problems can be easily solved by implementing a collaborative "round-trip" workflow solution.


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DIGITAL LAYOUT WORKFLOW BENEFITS

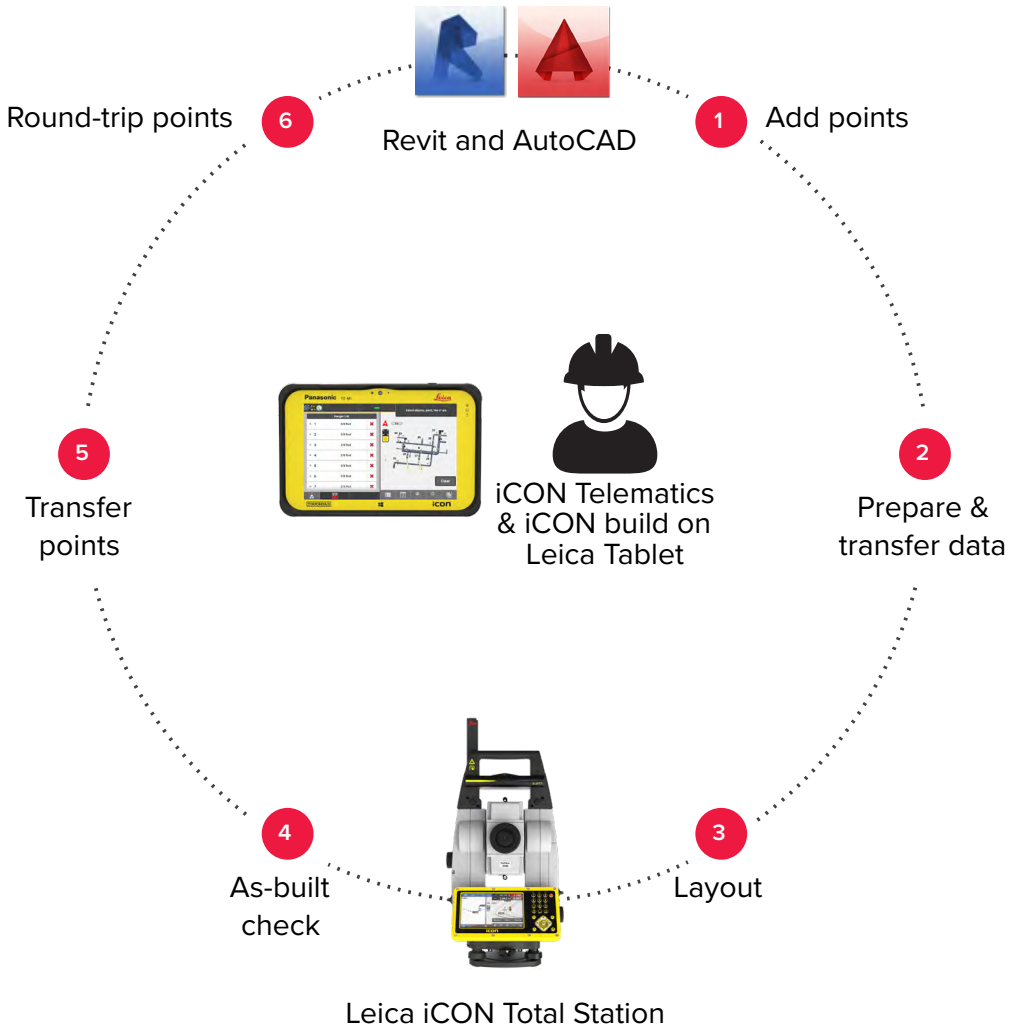
A best-practice approach includes model-based point creation, digital layout directly from the model in the field, as-built capture directly into the field model, and finally round-tripping the data back into Autodesk® Revit®, Navisworks® or AutoCAD®.

Enriching the construction process by working with a collaborative model in the field speeds communication time and helps eliminate mistakes that happen in the field when manual layout practices are in use. Construction teams that implement smart digital layout solutions benefit from reduced rework, increased productivity and improved profitability.

PRODUCTION LAYOUT WORKFLOW

BENEFITS:

- Complete interoperability 2D & 3D
- Intuitive, construction-oriented field software
- Ability to add or modify layout points in the field
- Flexible data transfer
- Ruggedized windows tablet
- Long range bluetooth



ENRICHING CONSTRUCTION FOR PRODUCTION LAYOUT

Prepping Model Data for Field Layout

For construction layout professionals, the digital layout process begins with the user determining which elements need construction layout points and then identifying at least two control points so the digital data can be oriented to the physical building in the field. The control points must be marked in the field and in the model so the coordinates can be easily aligned.

Projects such as residential concrete foundations can begin with paper drawings or 2D CAD drawings. For projects starting with paper, the foundation can easily be sketched directly in field software such as Leica iCON build, and layout points can be added directly in the field software. This type of digital layout is an excellent on-ramp into the BIM process. For projects using a CAD file, layout points can be created using software such as MS Point Prep for highly accurate replication in the field.

However, the most accurate way to add layout points is directly on a model using a tool such as Autodesk Point Layout or Leica Building Link. Points can be manually added, or the process can be automated by applying layout points to Revit families. For example, if layout points are added to a concrete pile cap family, all of the pile caps will automatically get layout points.

Once the layout points are prepped, the data is ready to be handed to the field team. The next step in the data prep process is to export the points in an ASCII file format (TXT or CSV), a plan underlay in 2D DXF and a model in 3D DXF polymesh. If the field team views reference models in the field, determine the viewer they are using and the file format they need for model viewing.

Once the DXF plan and model are imported, they will show up as an underlay to the points, which can be turned on or off as needed. For example, when laying out column locations, the plan view of the columns with points at all the columns can be used to identify the location in the field. This helps with orientation and provides context in the field.

Using high-accuracy tools such as total stations combined with intelligent software to apply construction layout points to the model and then transferring those points to the jobsite creates a “paint by number” plan for the contractors and installers. Enriching construction with high levels of accuracy streamlines processes, reduces the risk of errors, and improves predictability.

Image courtesy of Clark Builders

Digital Layout Accelerates Success at Clark Builders

Ninety to 100 points an hour – that's how fast the surveyors of Clark Builders typically move when they're on a project doing layout. The top-ranking general contractor, based in Edmonton, Alberta, Canada, delivers buildings and structures in the industrial, commercial, and institutional sectors, and concrete layout work is a key area of focus. Within the space of a year, the company streamlined its layout time by 25 to 30 percent after adopting the Leica iCON robotic total stations, GNSS and software.

Clark Builders first adopted robotic layout in 2011 using another brand of technology. Although the first set of robots increased their speed compared to manual methods, the technology was complex and required pressing multiple buttons in the right combination to accomplish a simple point layout. Transferring data from the field to the office required importing and exporting between a third-party software. Training involved weeks of trial and error, and field surveyors needed a high level of experience and expertise to do the job right.

As building projects became increasingly elaborate, with more angles, curves and slopes, the surveyors kept pushing the envelope, trying to find a better way to get the job done. One day, while the company was working on a three-level parkade, Courtney Gehring from Mountainview Systems stopped by to demonstrate the Leica iCON robot. "I was blown away by the iCON's ability to do surfaces easily, as well as its ability to do point and line layouts," said Jeff Gerber, who was Clark Builders' head surveyor at the time. "This was the technology we had been waiting for."

Speed and Accuracy Provide Big Efficiency Gains

In a matter of days, the surveyors mastered the iCON workflow. As the team finished up the three-level parkade, they used the iCON on half of the structure and their previous robot on the other half, carefully tracking the amount of time required to lay out columns and slab beds, set the tables and pour the concrete. It was a complicated project, with the tables and concrete sloped in all directions. The efficiency gains with the iCON were significant.

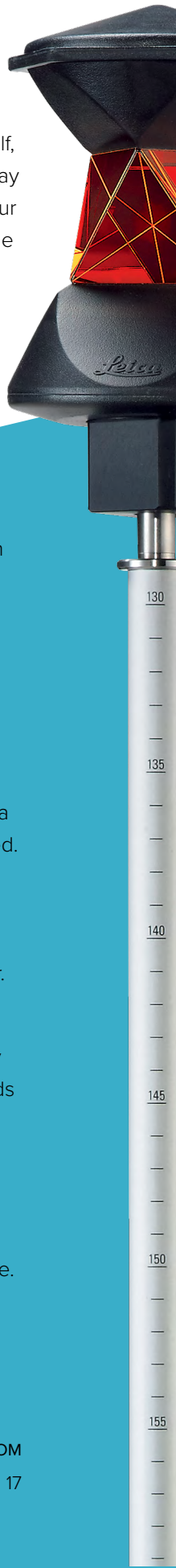
On another project, Clark Builders had to lay out HVAC core hole locations through a concrete slab under every seat in a theater. With their previous robot, the surveyors were able to lay out a maximum of 50 or 60 points per hour in this type of application. With the iCON, they were easily getting more than 80 points an hour at high accuracy.

Ease of Use Generates a Fast ROI

Ease of use was a key selling point for Clark Builders. In the field, the iCON makes it much easier to do basic and complex tasks. Moving the data between the field and office is also much easier. The team saves AutoCAD or Revit files as a DXF, with no additional imports or exports required. Points are overlaid perfectly on the drawings, which provides valuable information in the field. "The software automatically creates points at the ends of lines and centers the circles," said Gerber. "We just save it as a DXF and go."

To transfer field data to the office, the team simply exports a CSV or DXF file from the tablet and loads it into AutoCAD or Revit as required.

Because of the faster and easier workflow, the company now spends 25 to 30 percent less time on every project, which lowers survey costs, eliminates rework and keeps projects on schedule.



Enriching Construction for BIM QA/QC

Prepping Model Data for Field Layout

Recent hardware/software integrations have provided even greater flexibility by enabling BIM/VDC departments to easily perform QA/QC tasks in the field. Layout points can be added directly to an Autodesk Revit, AutoCAD and/or Navisworks model using the Autodesk Point Layout plug-in. In Autodesk Revit, points can be added to any geometry or line types with automated capabilities for floor slabs, walls, wall tracks, foundations, ceilings and families. In AutoCAD, there are also automated tools for MEP pipe and conduit stub ups/endpoints, hangers, sleeves, all line work types and tasks such as offsets and arrays of points, while in Autodesk Navisworks Simulate points can be easily added to all building components or lines automatically with the Mark Selections and Place Points tools.

The most critical element during the data prep process is establishing virtual control points in the CAD or BIM that exactly match the established control physically in the field. These control points allow the total station to be oriented on the jobsite so it can precisely locate and as-built points.

Once the control and layout points are all in place, the information needs to be stored in a way that will be easily accessible in the field. A popular solution is to use the Autodesk® BIM 360™ Glue® add-in (within Navisworks, Revit, or AutoCAD) to publish a lightweight version of the constructibility

model to the Autodesk BIM 360 Glue web service, which can then be synced with the Autodesk BIM 360 Layout app. A BIM 360 Glue administrator will need to set up the project and permissions for the team to access relevant project data.


“ EASILY PERFORM QA/QC IN THE FIELD. ”

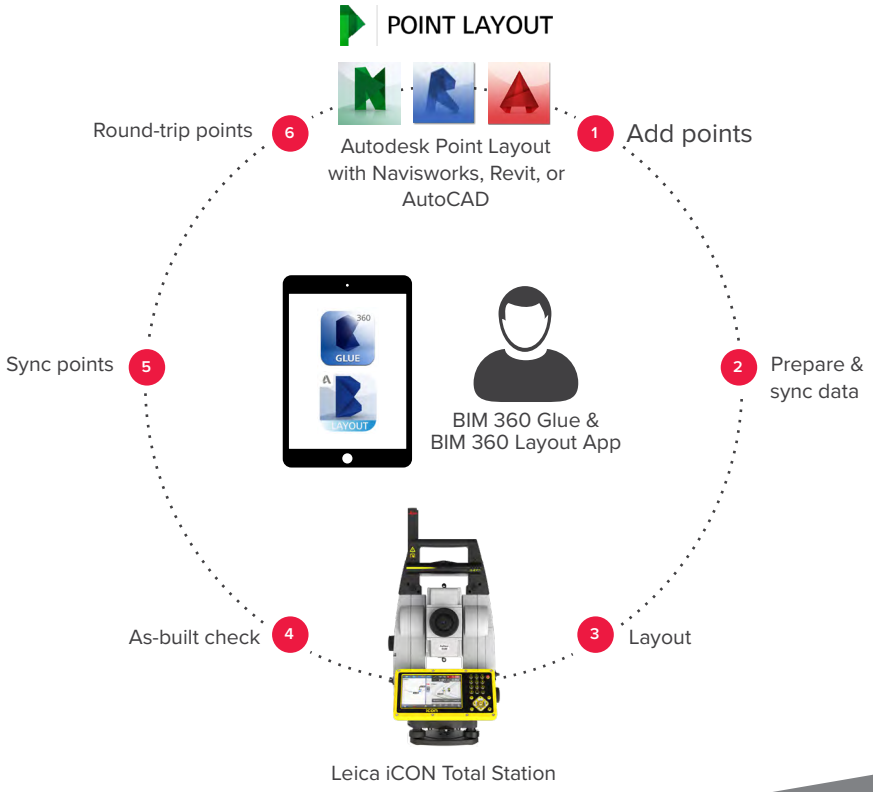
“INTEGRATED SOLUTIONS MAKE IT EASY.”

Image courtesy of Holder Construction

BIM QA/QC WORKFLOW

BENEFITS:

- Autodesk model-based layout & QA
- Leverage BIM 360 Glue investment
- Utilize standard iPad
- Wi-Fi connectivity



GETTING LAYOUT POINTS TO THE FIELD

Once the team has the model and points for layout, QA/QC or as-builting/back-checking, the next step is to connect to the total station. Field hardware solutions that are integrated with the Autodesk BIM 360 Layout app, such as the Leica iCON robotic total stations, make this process easy.

For a known point setup, the robot and tripod are located and leveled directly over one known control point location with a clear line of sight to the area that needs to be laid out or back checked.

Within the BIM 360 Layout app, the user can establish communications with the Leica iCON robot from the iPad WiFi settings and simply select the iCON device. Once a connection is made, BIM 360 Layout has a Robot Setup wizard that walks the user step-by-step from setup, to search, to backsight point, and completing setup.

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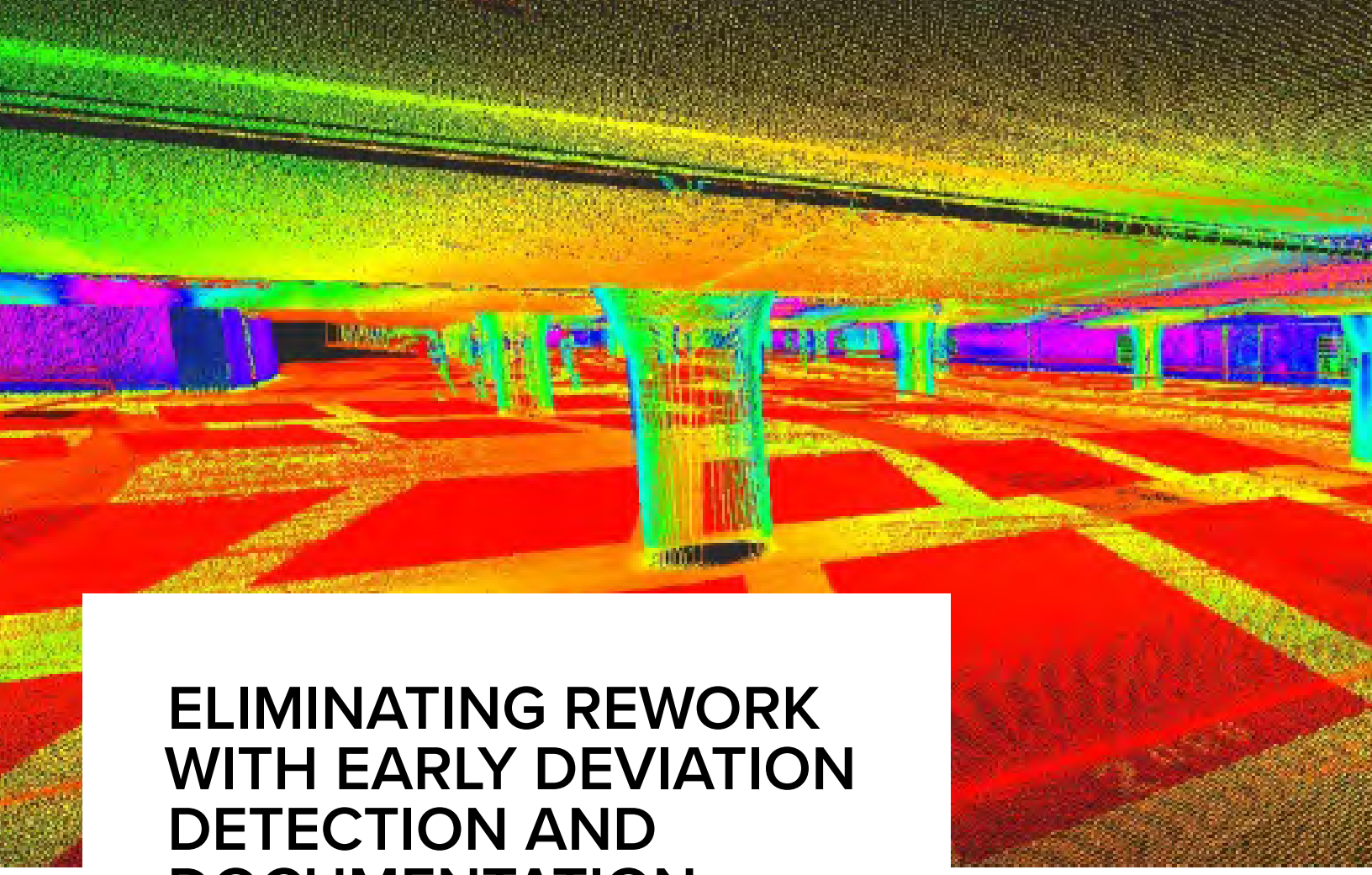
As construction progresses, the balance between speed and quality is difficult to achieve. Automated quality assurance tools provide valuable insights that help contractors plan better and head off problems before they materialize on the jobsite.

Once again, capturing point clouds using hardware that integrates seamlessly with a team's existing software can provide a streamlined workflow.



ELIMINATING REWORK WITH EARLY DEVIATION DETECTION AND DOCUMENTATION

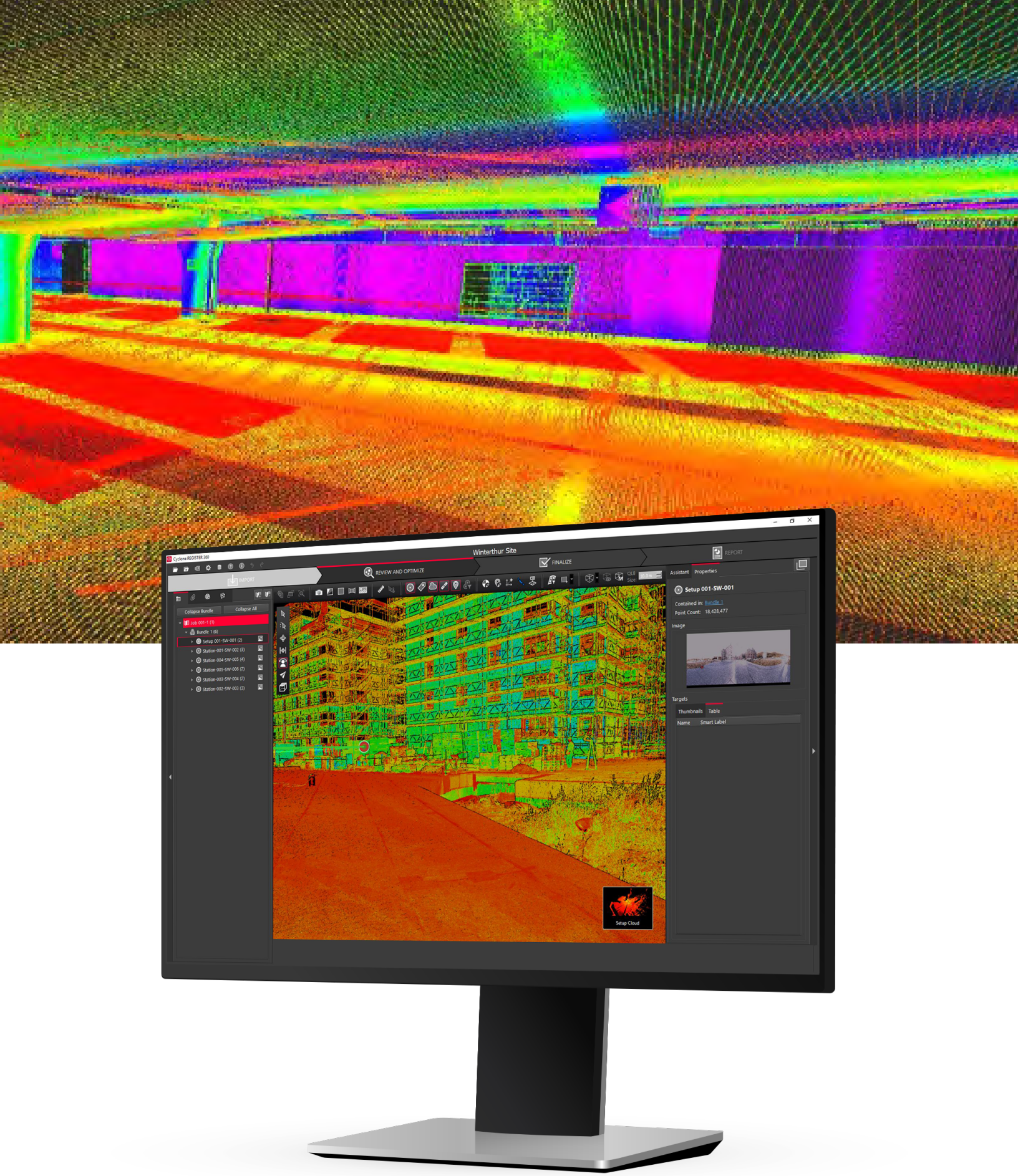
Validating Construction with Point Clouds

Laser scanning is the fastest and most accurate way to capture the complete jobsite so work can be evaluated on a weekly or even daily basis to assure the best quality construction.

This process starts with scanning all areas of the construction site to be analyzed. For example, scanning all components as they are installed can provide a time-lapse record with millimeter accuracy data on the pipes, HVAC, structural steel, floors, and rebar in the concrete slabs throughout the building along with the actual installation date. This information can be compared to the design to verify that all components are installed in the correct place.

If any errors are discovered, the design can be revised so that new components can be altered in the fabrication process instead of making costly changes onsite.

Laser scanning can also be used to quickly assess the slab flatness of concrete floors, easily calculate the extents of any areas that need to be adjusted and accurately determine the volume of material needed. This capability leads to more accurate material orders and less waste.


Winterthur Site
IMPORT
REVIEW AND OPTIMIZE
FINALIZE
REPORT
Collapse Bundle
Collapse All
Job 001-1 (1)
Bundle 1 (6)
Setup 001-SW-001 (2)
Station-001-SW-002 (3)
Station-004-SW-005 (4)
Station-005-SW-006 (2)
Station-003-SW-004 (2)
Station-002-SW-003 (3)
Assistant
Properties
Setup 001-SW-001
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Targets
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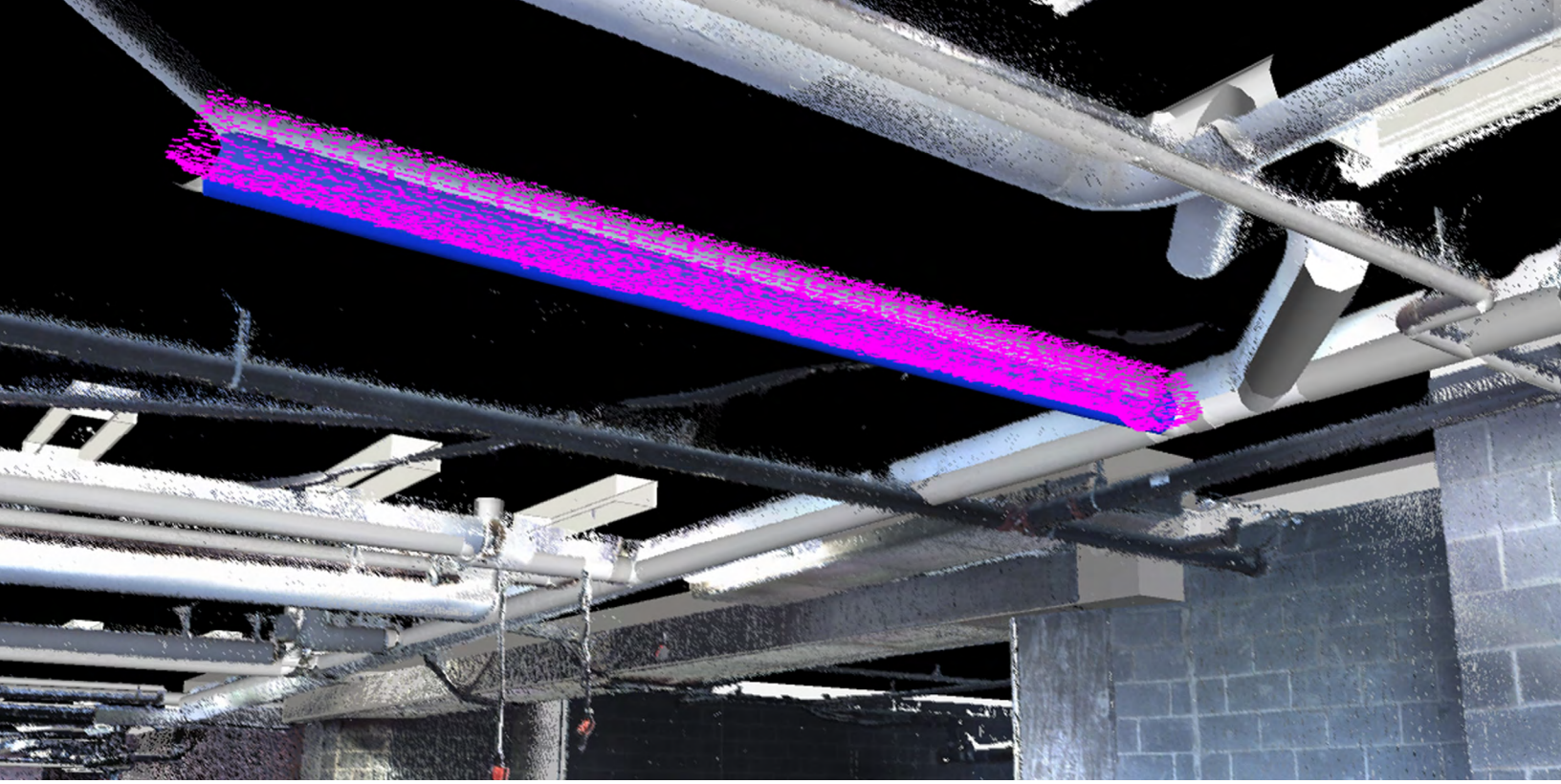
Table
Name
Smart Label
Setup Cloud



As in pre-design as-builting, advanced software and smart hardware/software integrations are making it easy to use point clouds in construction validation. For the most powerful point cloud management tools, professionals rely on Leica Cyclone software for a scalable solution that accommodates any scan project, from small interior renovations to high rise buildings to large infrastructure projects that span an entire city. The software is supported by the ultra-high speed server JetStream, which pulls in point clouds with no regeneration time. Professionals who need to share point clouds with other stakeholders in a non-BIM environment can use TruView Global, which can be accessed in any browser from desktop or mobile devices.

Automated Deviation Detection

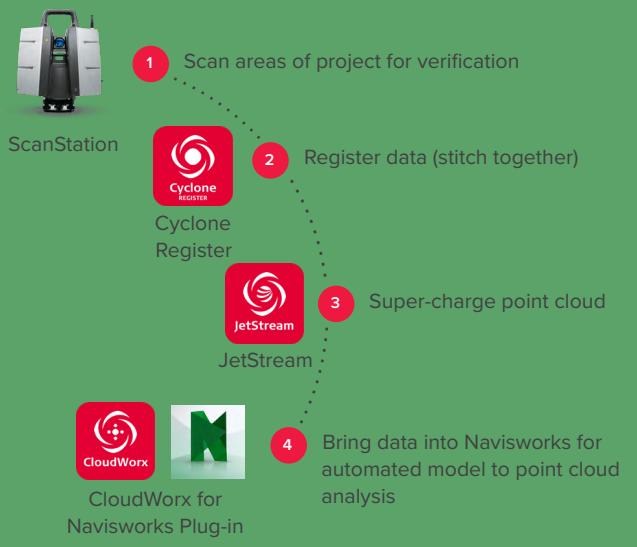
State-of-the-art automated deviation detection is achieved by starting with Cyclone Register in conjunction with JetStream. This solution supports use cases ranging from automatic registration and visual alignment to the addition of survey control, extensive error reporting and the ability to store multiple user coordinate systems for easy insertion of the point cloud data into CAD models.

With the Leica CloudWorx for Navisworks plugin, professionals using Autodesk Navisworks can perform automated clash/deviation detection between point clouds and models with issue management, making it easy to identify and correct problems before they affect the construction schedule. The rich detail provided by point clouds allows users to see and truly understand the real world conditions compared to design intent. Access to powerful tools such as slices and limit boxes, cloud color mapping control, and TruSpace panoramic views provide increased functionality. Additionally, users can access optional data sources such as Leica Cyclone or JetStream for ultra-high speed point cloud rendering. These and other benefits empower professionals to increase their productivity by 50% or more over the built-in capabilities of Navisworks.

DEVIATION DETECTION WORKFLOW

BENEFITS:

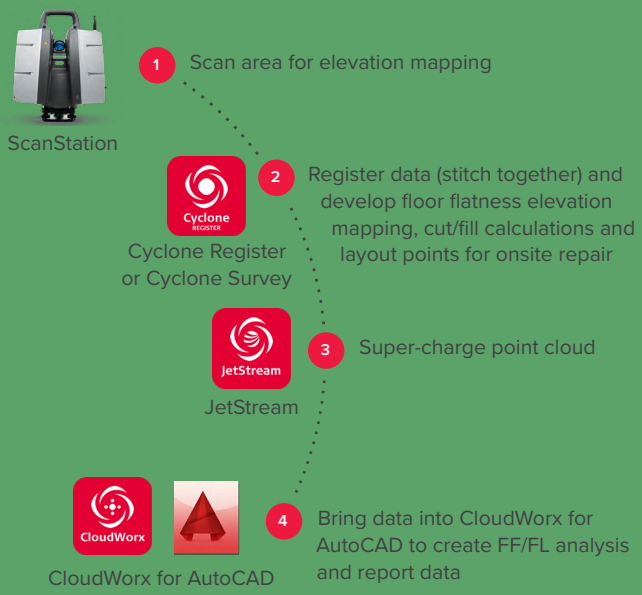
- Automated point cloud to model deviation detection
- Comprehensive, feature-rich point cloud management
- Ultra-fast point cloud server - fully interoperable
- Deviation detection status management



SLAB FLATNESS WORKFLOW

BENEFITS:

- Dramatically reduces amount of time required to capture measurements
- Enables FF/FL calculations directly from scan data
- Creates visual data that can be read by experts and novices
- Provides easy and high-accuracy analysis for increased confidence



Fast and Accurate Slab Flatness Analysis

There are several ways of looking at slab flatness, ranging from very visual elevation mapping to following the ASTM E1155 standards for analysis (FF/FL). Whatever your approach, laser scanning gives you valuable insight that makes your job easier.

Elevation Mapping: Since scanning captures so many points, you can simply color the cloud by elevation to immediately reveal any high or low points in the concrete pour. With a few simple button clicks, you can establish the extents of the high and low areas and apply discrete points to the boundaries. These points maintain their coordinates, so they can be uploaded to a total station and laid out in the field to visually communicate any required changes to project stakeholders. The actual volume of material can be computed from the laser scan data as well, giving you more confidence in your material orders.

FF/FL ASTM E1155: Using scan data with the "points on a grid" functionality of Leica CloudWorx for AutoCAD or Cyclone Survey enables you to easily locate grid lines to meet the ASTM requirements and apply the elevations from the point cloud data. This data can then be exported to the Leica FF/FL calculator for analysis based on your project specifications. The scan data can also be used to create a solid surface that can then be compared with a flat plane for fast and accurate cut/fill comparisons. The combination of high-quality point clouds with extremely fast rendering capabilities and intuitive tools makes it easy to leverage point clouds for an efficient, informed and validated construction process.

Simple Point Cloud Utilization

For point cloud applications that don't require deviation detection or slab flatness analysis, native point cloud data from the Leica ScanStation P16 can be used directly in Autodesk ReCap for a basic approach.

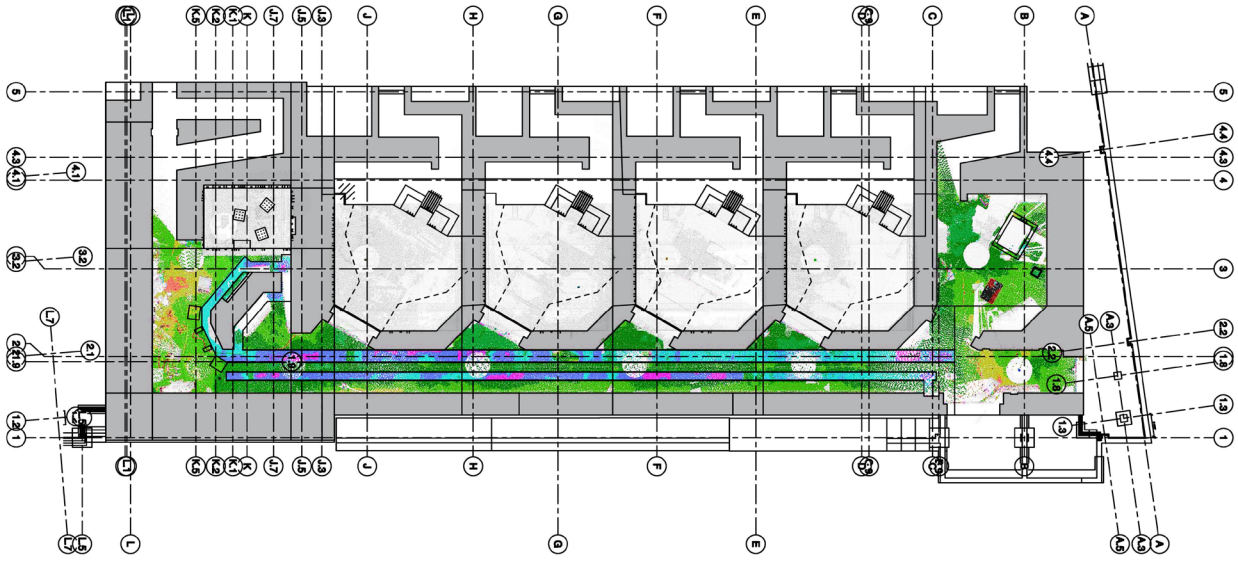
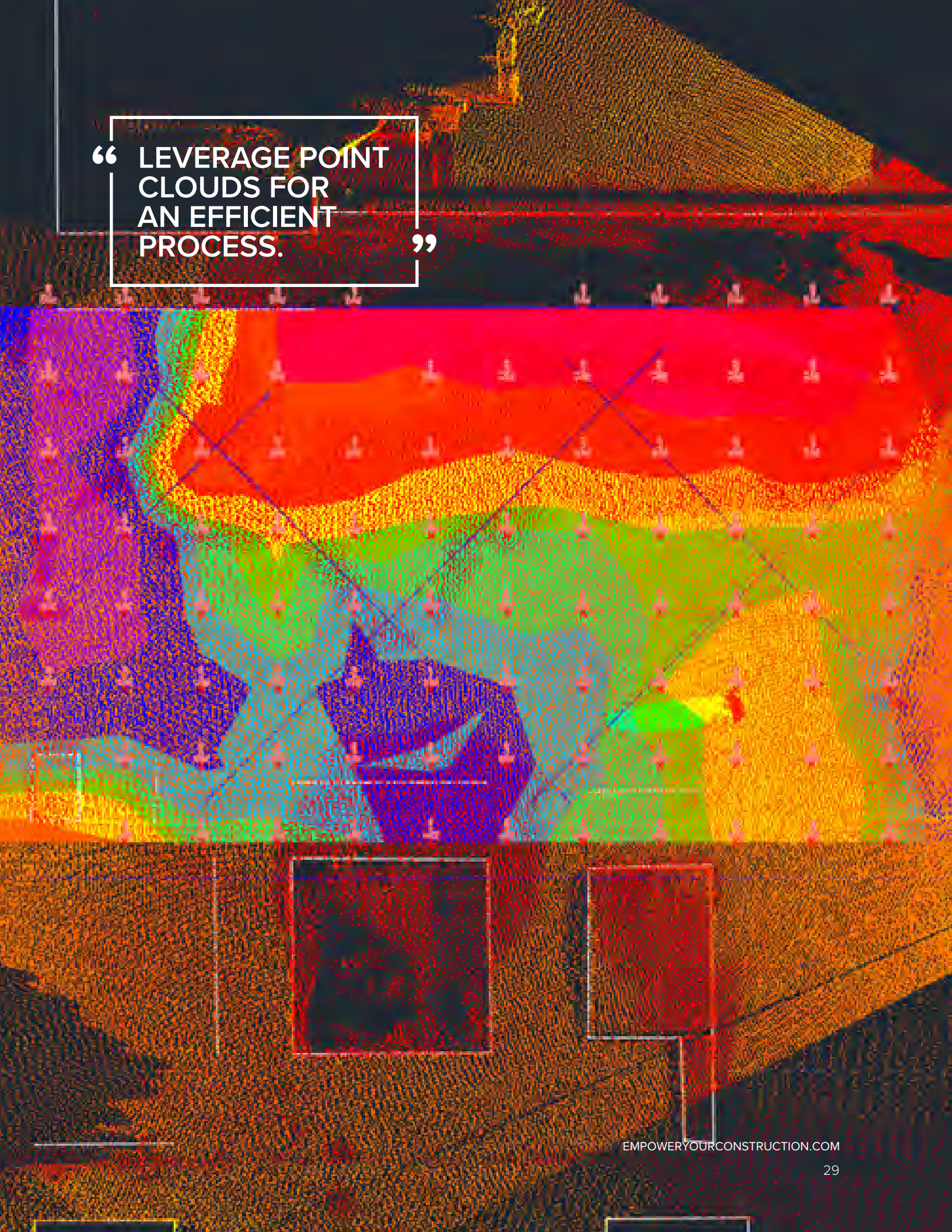


Image courtesy of Brasfield & Gorrie


“ LEVERAGE POINT CLOUDS FOR AN EFFICIENT PROCESS. ”

NEW OPTIONS FOR REALITY CAPTURE

Laser scanners aren't the only ways to validate construction. New solutions create exciting opportunities to capture even more information for even greater productivity and risk reduction.

For example, lightweight, wearable reality capturing sensor platforms such as the Leica Pegasus:Backpack combine cameras and LiDAR profilers to enable complete documentation of a building for full life cycle management. By using SLAM (simultaneous localization and mapping) technology and a high precision IMU, the Pegasus:Backpack ensures accurate positioning without GPS satellites, survey control points, total stations or WiFi. Data from the backpack can easily be pulled into CAD and BIM environments with Leica CloudWorx software powered by JetStream for ultrafast point cloud loading and rendering.

Another innovative solution for reality capture that holds tremendous potential for building construction is the unmanned aircraft system (UAS), also known as an unmanned aerial vehicle (UAV) or drone. UAVs such as the Leica Aibot easily capture aerial views of construction sites for visual inspection, and high-resolution photos can be converted to point clouds for further analysis or archival/documentation purposes. Using Leica CloudWorx software, the data can be transferred to CAD or BIM to add a greater level of project insight.

A COMPLETE 3D BIM LIFECYCLE

The ultimate goal is to fully round-trip the data to create a complete 3D BIM lifecycle. Point clouds and imagery captured on the site are used to inform the model, create the proper documentation for design and calculate data points from the design model. These points are then transferred to the field to create a paint-by-numbers installation for contractors. Finally, the newly built structure is then scanned during construction, and these scans are checked against the model to assess work completed at specific points in the schedule to ensure the structure is built correctly. As additional scans are captured and imported, they continue to inform the model.

This workflow reduces errors and provides a higher level of predictability of project outcomes.

Today's construction industry is characterized by shorter building cycles, shrinking budgets and growing expectations for accurate data on demand. Although this situation presents numerous challenges for contractors, it also creates tremendous opportunities for firms that wish to differentiate themselves in an increasingly competitive market. Whether you're actively embracing BIM or just looking for a way to increase efficiency and transparency on the jobsite, integrating accurate as-built data capture, digital layout workflows, and early deviation detection and documentation can help you reach your goals.

To learn more, visit **www.empoweryourconstruction.com**.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With close to 200 years of experience pioneering solutions to measure the world, Leica Geosystems products and services are trusted by professionals worldwide to help them capture, analyze, and present spatial information. Leica Geosystems is best known for its broad array of products that capture accurately, model quickly, analyze easily, and visualize and present spatial information. Leica Geosystems is part of Hexagon, a leading global provider of design, measurement and visualization technologies that enable customers to design, measure and position objects, and process and present data.

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