WORKFLOW 4.0 SPECIAL REPORT

ZERO SURPRISES:

New QA Technologies that Reduce Risk, Help Maintain Schedules & Improve Construction Margins.

Learn how you can reduce your contribution to the $450 billion dollar construction industry problem.

Authored by:

WorkFlow 4.0

3D documentation tips, tactics, ideas and opinions

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Chapter 1: The $450 Billion Problem

Each year, the construction industry spends between 9 and 12 trillion dollars putting work in place worldwide. Unfortunately, the efficiency of the industry has remained stagnant over the last several decades. Some studies estimate as much as 30% to 40% of the cost of building is due to waste and inefficient practices.

Mistakes like this cost the industry more than $450 billion each year. Image source: www.viralnova.com/31-building-fails-gallery

A substantial part of that challenge comes from rework on the job site. Most studies and surveys estimate that between 5% and 12% of the cost of a building is due to rework. This drives the large contingencies every participant in the supply chain carries to protect themselves. Worldwide, this is at least a 450-billion-dollar problem, every year.

Why Do We Have this Problem?

The amount of rework in the marketplace is driven by the industry's workflow and the tools they've previously had available to them to QA work—until now. Traditionally, projects are designed and engineered up to the point that it establishes a design intent for bidding or negotiating a construction price. But, the project does not go so far as to be a complete and coordinated design. Once a general contractor is brought on board, they engage subcontractors who are each responsible for individual scopes of work in the building. These subcontractors are ultimately responsible for finalizing the design per the design intent, applying means and methods to that design intent to ensure it is buildable within the budget and schedule, and fabricating and installing the work. The general contractor is responsible for coordinating all these separate teams and their scopes of work. What could possibly go wrong?

...as much as 30% to 40% of the cost of building is due to waste and inefficient practices.

Chapter 2: Current QA Processes

Laying Out the Work

One of the first critical tasks on a construction site is establishing dimensional control. Typically established by a registered surveyor, the overall control will then be extended by the GC or a specialty subcontractor into the building site for layout of foundations and structure. These control points enable the initial subcontractors to use total stations to locate where structural elements should go with a high degree of precision. These control points are located with a tolerance of +/- a few hundredths of a foot.

As structural elements are installed and completed, that control is further extended into the building using grid offsets or other markers that the subcontractors can use to install their work. These are established from

Each scope has its own acceptable installation and fabrication tolerances, and these may or may not be coordinated with each other.

the control points, and are usually marked with chalk lines. From there, the subcontractors will either use those offset intersections to set up total stations inside the building, or more likely they will use more traditional measurement tools such as tape measures to pull dimensions from those offset lines. These measurements, of course, have less precision and lower accuracy.

The job site dimensional control provides the foundation for both installation and QA. By the time one is several layers deep into the dimensional control of a job, busts of +/- 1 to 2 inches from absolute accuracy are not uncommon. As long as relative accuracy remains high, these kinds of layout errors are just part of building a project. There is no perfect measurement device, and correspondingly no perfect layout device. This is why the industry has tolerances, though these cause their own problems...

Varying Tolerances Can Breed Installation Errors

Another challenge one encounters are the varying tolerances in the industry. Each scope has its own acceptable installation and fabrication tolerances, and these may or may not be coordinated with each other. Imagine trying to install drywall to +/- 1/8 inch over 20 feet when the framing sub's tolerance was +/- half an inch over 20 feet. On top of layout tolerances, these fabrication and installation tolerances create further variances between the intended position of work in the field and the actual installed location. To cope with the layers of tolerances that exist within the building industry, two main strategies have emerged.

Varying tolerances from different scopes of work can lead to very expensive mistakes.

One strategy is to simply design complex mounting and connection details that can mitigate the tolerance challenges between systems and scopes of work. If these connections are going to be exposed, this is a very expensive and fabrication heavy solution. So, it usually happens with high-cost systems like glazing. If they aren't going to be exposed, less aesthetically pleasing solutions like channel anchors, unistrut, and threaded hangers help manage these tolerance-related issues. These solutions ultimately allow a new scope of work to be installed as intended regardless of tolerance-related variances in scopes of work that came first. However, this doesn't always work, particularly when there has been a mistake that is more than just a measurement or installation tolerance issue.

Field Fabrication…So Last-Century

The second strategy is field fabrication. This allows the ultimate flexibility to deal with field variances, but it has its share of problems too. It can result in material waste and increased costs, with cuts of stock lengths being made on demand rather than optimized across the entire job. Field fabrication has the least predictable schedule profile as all the work is done in the elements, and it doesn't lend itself to task specialization as well as factory work does. It also tends to have a higher risk for mistakes that require rework, whether it is from miscalculating slopes for gravity-slope pipes, or simply placing equipment or valves in a place that can't be accessed after other work gets installed.

Field fabrication is an inefficient and expensive way to solve the problem. Image courtesy of Maximus Oilfield Services, LLC.

For most of the 20th century, this was the predominant solution for nearly all scopes of work, and for good reason. As building systems became more complex, there were no technical tools available to understand the complete picture of what was to be installed. So, it was far simpler to have a trade go out and build around whatever was already installed than it was to try and figure it all out up front. This first come, first served mentality still exists on the modern job site despite the emergence of tools such as CAD, BIM, and processes like 3D Coordination that now make figuring it out up front possible.

Spot checking means a lot of mistakes are not caught early enough, resulting in expensive rework and schedule delays, putting the whole project into a reactive mode.

First Come, First Served

The "I was here first" mindset causes its own set of problems. It is almost impossible for multiple trades to be working in the same area at the same time as they'll conflict with each other's activities. So, the first trade moves in, completes their work, and the next trade begins their job. Whoever is first in line sets the stage for the next trade in line. So, if subsequent trades are planning on taking advantage of pre-fabrication, they are counting on everyone before them to have completed their work *just right*. Or, they are only partially pre-fabricating with a lot of field fabrication built into their work to allow for field adjustments against other people's variances. Unfortunately, every time one mixes field fabrication with pre-fabrication, both material and labor waste occurs.

Spot checking with a tape measure or even a total station is wholly inadequate for today's complex projects.

Spot Checking Yields Spotty Data

With all this potential for variances between what was supposed to be built and what actually gets put in place, you'd think there would be a robust mechanism in the building industry to find, document, and resolve these kinds of issues. Not so much!

The end result of all these challenges is that the installed work in a modern building usually bears only a passing resemblance to the drawings. Even more money is wasted during the operation and maintenance of a facility, as these discrepancies cause waste and rework for the owner long after the construction is complete.

Because construction quality control has been underserved by technological advances, the tools used to check installed work are the same ones used to lay it out in the first place. The efficiency of these tools simply doesn't allow for any reasonable workflow to check all the installed work. So, the industry relies on spot-checking to verify its work placement quality. Usually, 5% to 10% of the installed work is measured in the field after installation to check conformance with the specified tolerances for that scope of work. If most of those elements pass, you assume the rest will as well. If something is far enough out of tolerance to throw a red flag, you check another 5% or 10% and repeat…

Unfortunately, this means a lot of mistakes are not caught early enough. Instead, they only get discovered when someone goes to install their follow-on work and it doesn't fit. At this point, you not only have the material and labor costs associated with rework, you also have potential schedule impacts as it will now delay the work in this area. This puts the whole project into a reactive mode as they deal with these sleeping problems one after another. It also causes them to rush other parts of the work to make up the schedule, which just increases the odds of another mistake occurring in that work.

Competitive Pressures and Project Complexity Deliver Poor Results

The end result of all these challenges is that the installed work in a modern building usually bears only a passing resemblance to the drawings, with too many differences to count. Owners and operators usually build "as-built" drawings into their contracts requirements as a result of these inherent variances between the builder's intent and what actually was built.

However, there are also a lack of tools to track those discrepancies and help facilitate updating the drawings. So, even with the best intents, the subcontractors, general contractors, engineers, and architects engaged in the process of creating those final as-built drawings can only do a partial job of it. As such, even more money is wasted during the operation and maintenance of a facility, as these discrepancies cause waste and rework for the owner long after the construction is complete.

None of this is intentional, or due to any one player in the construction of a building being a bad actor. The current workflows, flawed as they are, have evolved over the last century in response to the increasing complexity of buildings, the heavy pressures on fees and profits within the competitive market, and the tools and technologies that were available to solve the problems people were experiencing. With all the challenges noted above, it is amazing that this problem isn't worse. The current 5% to 12% of rework related costs were the best that could be delivered given the conditions.

Chapter 3: New Software Tools for Better QA

A Changing Reality Driven by Technological Innovation

Fortunately, the construction industry has seen an explosion of technologies over the last 15 to 20 years that are all coalescing to help solve the problem. Building Information Modeling (BIM) has created a situation where accurate models of the design and fabrication intent are available on most major job sites around the world. Reality Capture technologies such as laser scanning and photogrammetry are creating a wealth of as-built information on these same job sites. For the first time in a long time, it is again possible to completely design and coordinate a complex facility—and to completely document what gets built in the field.

A 3D coordination meeting in progress . Image courtesy of Victaulic.

Admittedly, possible does not necessarily mean probable or profitable. The workflows to execute on this promise are uncharted and the tools are relatively new. The way buildings are built will not change overnight. We are at the early stages of seeing this change manifest itself within the industry. That said…

Recent surveys show that a large majority of major projects worldwide now have incorporated 3D coordination workflows as part of their building delivery process. BIM is now surpassing 2D as a design delivery tool at most medium and large firms. Laser scanning is rapidly being accepted as a tool to document existing conditions at all stages of design and construction. All the parts and pieces are in place to fundamentally tackle rework related costs in the construction industry and help solve this $450 billion dollar a year problem. What we need are tools that take advantage of these converging trends and make it efficient and profitable to do things better.

All the parts and pieces are in place to fundamentally tackle rework related costs in the construction industry and help solve this $450 billion dollar a year problem.

New Software Tools Promise to Change Project Execution Forever

ClearEdge3D has been on the leading edge of technological innovation that is fomenting the adoption of reality capture and scan-to-BIM workflows. The company's best-in-class computer vision technologies have allowed thousands of companies to streamline the process of taking laser scans of existing conditions and translate them into fully functional BIMs.

ClearEdge3D has applied that technology and their industry experience to the problem of "out of tolerance" construction work and developed Verity™, the first reality capture-enabled construction quality assurance tool.

Verity dramatically reduces the financial impact of poorly constructed work by identifying out of tolerance or missing elements early in the process. This results in reduced risk, more profitable construction projects, more accurate as-builts, and fewer schedule delays.

VERITY
Construction Verification Software

The software compares point clouds against design and fabrication models, allowing you to verify 100% of your work in the time it currently takes you to spot check 5%. Verity helps you find construction mistakes before they become expensive problems.

Verity compares point clouds against design and fabrication models, allowing you to verify 100% of your work in the time it currently takes you to spot check 5%.

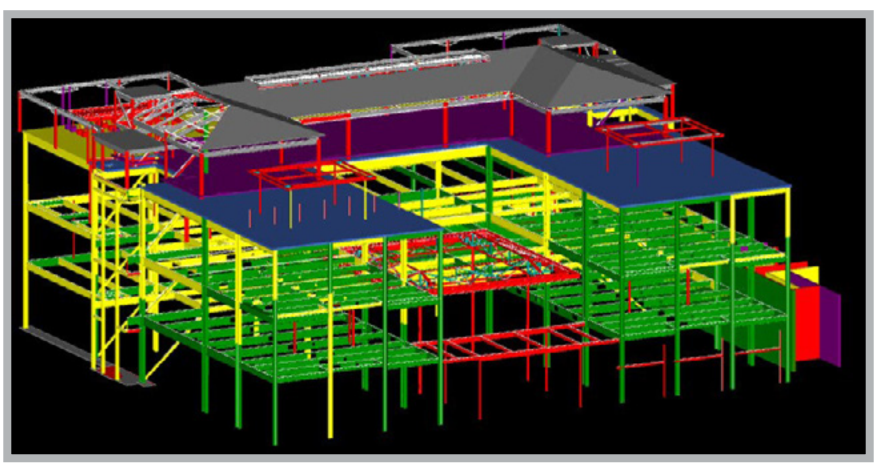
Verity in Action

Verity acts as a companion application to Autodesk Navisworks, pulling and pushing information to allow for the simultaneous analysis of each element individually and in context of the SOW and the project.

Verity shows the as-built in blue and the as-designed in purple.

The software works by comparing scans of the as-constructed conditions in the field to the 3D-coordinated models using the same award-winning computer vision algorithms behind ClearEdge3D's EdgeWise product line. This allows the software to use hundreds of thousands of measurements per element to provide a far more detailed and complete quality check of the object's conformance to the design.

The Verity software detects whether a modeled element has been installed and then fits the geometry from the coordination model to the adjacent points that best match the geometry. This provides an automated first pass at identifying and quantifying the installation status and conformance to tolerance of each analyzed item. Using this methodology, Verity can provide detailed variances between the location where the item was installed and where it was supposed to be installed. This includes maximum, vertical and horizontal displacement, as well as twist, vertical rotation, and horizontal rotation. The software also generates heatmaps of the points against the *as-designed* geometry to visualize rotational variances, and against the *as-built* geometry to look for deformation of the object.



Verity's easy to understand "stoplight" classification system gives you an overview of the construction accuracy.

Verity graphically displays each item, the points associated with it, and heatmaps of those points against both the as-designed and as-built location of the item, along with a tabular view showing each item and the numerical variances that have been quantified. This allows each item to be quickly and efficiently reviewed in the software by an experienced construction professional. In cases where the algorithms are unable to make a correct assumption, there are tools to allow the user to easily make manual adjustments or tell the algorithm what points to fit to. All these changes update the numerical comparisons between the as-intended and as-built geometry.

This QA process also creates a documentation mechanism, with the ability for the reviewer to note downstream actions and concerns as they check each item. Once the review is completed, Verity's reporting tools allow the user to take that metadata and organize their reports accordingly. There are a variety of reporting options including CSV exports of item tables and HTML reports of the table and individual items. The software also allows the user to push all the variance data back into Navisworks so the resulting NWD can serve as a fully navigable 3D report for people to view in Navisworks's Freedom viewer.

Discovering an issue is just the first step in the process of resolving it. One's first question might be whether the identified mistake is even a problem. Verity allows you to export the as-built position of each element back to the Navisworks model so you can run clash detection on what was installed and understand how it will impact future work in those areas.

If the issues don't warrant a fix in the field, users can then export just the points associated with out of tolerance elements that need to be updated in the as-built drawings. This can be given to whoever is responsible for making those changes as both documentation and a guide for where to change their models in their original authoring tools such as Revit or Microstation.

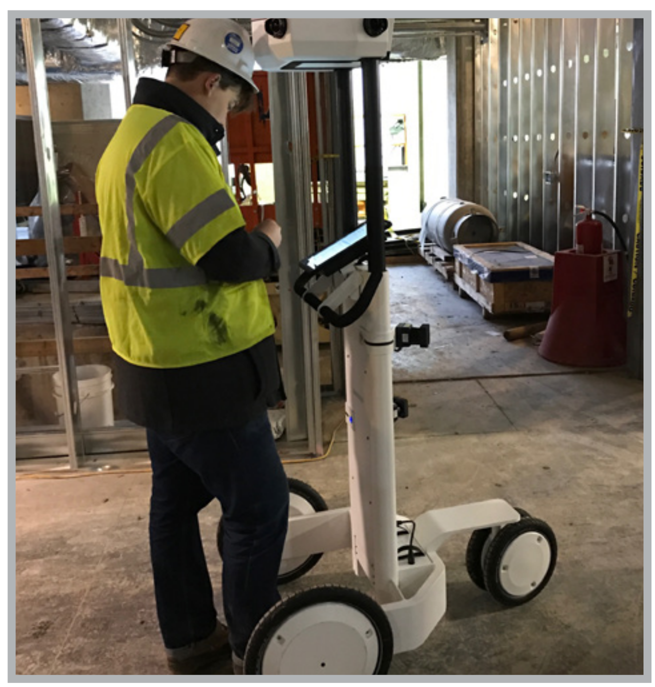
See detailed variances between the location where an item was installed and where it was supposed to be installed. This includes maximum, vertical and horizontal displacement, as well as twist, vertical rotation, and horizontal rotation.

Chapter 4: New Hardware Tools for Reality Capture

While many large general contractors already have laser scanners and the expertise to use them in-house, this is not yet the case at most companies. Laser scanners have historically been prohibitively expensive for companies without a clear business model for gaining ROI from the equipment and the operators necessary to run it. However, this past year has brought a number of new hardware solutions to the table that seek to dramatically lower the costs associated with reality capture on the job site.

Mobile Mapping

One approach to lowering the costs of capture is to attack the actual capture and registration process and make it dramatically more efficient. Mobile solutions attempt to do just this by capturing as you navigate a job site rather than requiring stationary scan locations. All this is done using sophisticated SLAM (Simultaneous Localization and Mapping) software that provides a single registered and textured point cloud as the output.



Technologies such as mobile mapping have enormous potential for data collection on site. Image courtesy of PrecisionPoint, Inc.

Traditional terrestrial scanners are rapidly dropping in price. With some new scanners under $25,000, the cost of buying a scanner is now almost an order of magnitude less than it was 5 years ago.

This has numerous benefits for construction scanning as it tends to reduce shadowing, provides more evenly spaced point data, and requires much less field time to capture. The primary downside is accuracy, as many of these solutions use lower precision sensors. And, even those using the highest precisions scanners will have lower absolute accuracy compared to a surveyed terrestrial data set. However, the newest generation of solutions is providing accuracies much closer to that of surveyed terrestrial scanning, frequently making the trade-off worth it in terms of capture and processing times.

Commodity Laser Scanners

At the same time, traditional terrestrial scanners are rapidly dropping in price. With Faro and Leica both offering new scanners at roughly $24,000 and $16,000 respectively, the cost of buying a scanner is now almost an order of magnitude less than it was 5 years ago. The LASiris VR from NCTech and other hybrid sensors like Matterport are offering even lower price point 3D scanners, though with lower precision results. While none of these low-cost solutions will deliver the same precision and accuracy that a $100,000 laser scanner will, depending on your use case they may be good enough at a much lower price point. This trend is only going to continue as mobile mapping and passive solutions continue to provide competitive pressure on the terrestrial scanning markets.

Rather than scanning and then separately capturing images, sometimes requiring a different piece of equipment, new scanners are trending towards simultaneous capture of RGB and even infrared imagery as the laser is recording range information. This has a big impact by dramatically reducing the time in the field needed to capture passive data during scanning. This should spark a sizable increase in how much data is captured with RGB and infrared information.

Although accuracy is still an issue, drones represent the future of construction site data collection. Image courtesy of PrecisionPoint, Inc.

Photogrammetry and UAVs

We've also seen many more photogrammetry-based solutions on the marketplace. The incredible explosion of UAVs in the marketplace for both professionals and hobbyists has dramatically increased the number of platforms capturing data. This has created a demand for software solutions to manage and process all that data into something meaningful for the AEC space. Pix4D, Sky Catch, Drone Deploy, Alive, and many other solutions are all racing to fill that vacuum. With them comes significant funding to create photogrammetry solutions for the built environment, including terrestrial photogrammetry and videogrammetry with tools like Pointivo and Pix4D.

All this adds up to a rapid pace of innovation in the passive capture space, and we are already seeing photogrammetry-based solutions that can compete with mobile scanning accuracies at a fraction of the price. Photogrammetry may never completely replace active sensors like LiDAR, but it is well on its way to being a valuable companion and even supplanting laser scanners in certain use-cases.

Chapter 5:
Case Studies of New QA Workflows

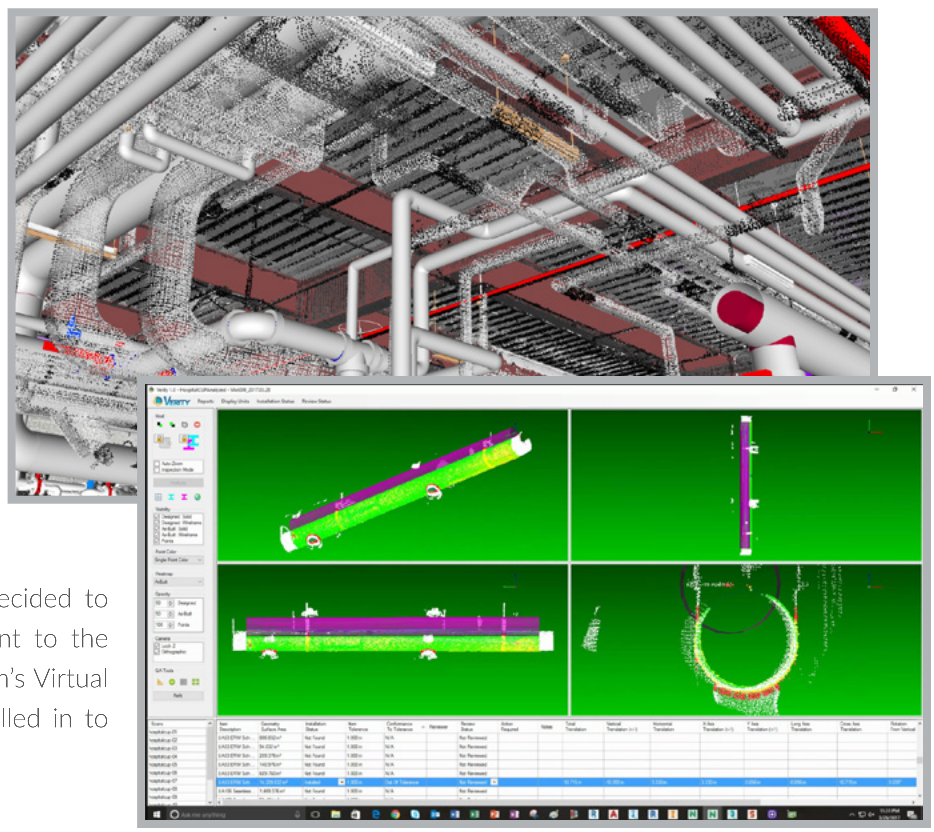
Verity Helps Beck Keep the Water Flowing at Hospital by Finding Pipe Installs Improperly Documented

Verity Updates As-Built Documents for Plant Room

The Beck Group ensured that the owners of a renovated hospital received accurate as-built documents by using new construction verification software from ClearEdge3D to find pipes that hadn't been installed according to the design plan. Beck used the new Verity construction verification software to analyze laser scans of the plant after renovation in order to provide more accurate as-builts of the renovated space.

The Project: Central Utility Plant at Texas Hospital

The Beck Group, an interdisciplinary architecture and construction firm based in Dallas, was wrapping up a major MEP renovation at a central utility plant (CUP) in a Texas hospital. More than 1,000 mechanical, electrical and plumbing (MEP) elements had been installed during the project. At the end of the project, Beck decided to compare the as-built conditions in the plant to the design model to flag any deviations. The firm's Virtual Design & Construction (VDC) team was called in to scan and analyze the data.



Verity works on all scopes of work including MEP, steel, concrete, walls and more.

Verity's "stop light" variance classification gave Beck a quick overview of construction quality.

In addition to a written tabular report showing element deviations, Verity generated a color-coded schematic of the site in Navisworks.

The Challenge: Limited Time in a Densely Packed MEP Space

The plant included 10,000 square feet of floor space tightly packed with conduit and pipe runs serving the hospital floors above. Beck spot checked the as-built locations and positions of the major features with TotalStation and tape measures but found that workflow to be time consuming. The firm opted to perform additional 3D laser scanning in the space as a proactive measure to verify all the CUP elements.

The Solution: Verity Construction Verification Software

Beck had been working with ClearEdge3D as a beta tester of a new automated construction verification software called Verity and decided to deploy it on the hospital CUP. Verity analyzes laser scan point clouds of recently constructed work and compares them against the design or fabrication models to determine the accuracy of the as-built elements. Out-of-tolerance work is highlighted including specific details on installation variances, rotation errors, twist, and sag.

The Workflow: Laser Scan Point Cloud and Verity

Beck's VDC team collected 13 scans in two hours inside the CUP, even as workers completed renovations. The scans were registered and loaded into Navisworks along with the design model. Verity pulled more than 1,000 MEP elements from the Navisworks model and analyzed them to a tolerance of one inch.

The Results: Verity Helped Beck Deliver 100% Accurate As-Builts to their Owner

In addition to a written tabular report showing element deviations, Verity generated a color-coded schematic of the site in Navisworks. Beck queried each feature in the report and found that most steel, HVAC and sprinkler members were within the designed location tolerance.

Verity found that many of the water pipes smaller than six inches were not installed within the location parameters of the coordinated model. Beck's VDC teams investigated and discovered the pipes were often installed several feet from their locations in the design plans and as-built drawings. This was not a mistake; the pipe installers had found a more efficient way to route the pipes and install the valves once they were onsite. However, the subcontractor hadn't marked the changes on as-built drawings and Verity was able to provide a more accurate as-built of the renovation.

"We went into this as a beta demonstration not expecting any actionable information, but Verity helped ensure we turned good information over to the hospital owner to maintain and operate the building."

- Kelly Cone, Former Director of VDC, The Beck Group

The Conclusion: Verity Helped the Hospital Owner Get 100% Correct As-Built Drawings

As with many as-built spot checks, the work focused on a small percentage of the larger pipes, which were within reasonable tolerances to design. Verity, however, examined the locations of every element in the central utility plant, finding that the smaller water pipes were not located where they were shown on the as-builts. Beck required subcontractors on the project to create new as-built drawings and submit them to the general contractor and the owner at no additional charge.

DPR Avoids Substantial Construction Delays by Finding Out-of-Tolerance Interior Steel Beams with Verity

Verity Identified As-Built Deviations in 50% of Horizontal and Vertical I-Beams

DPR Construction eliminated what could have been a significant delay in the construction work on the exterior of a new multi-story retail building by finding twisted, missing or poorly aligned steel beams in the interior structure. The company used ClearEdge3D's new Verity construction verification software to analyze 3D laser scans of the steel structural framework to identify precisely where the as-built condition deviated from the design model.

The Project: High-End Retail Site in Downtown Nashville

DPR Construction Inc., a commercial general contractor and construction management firm based in Redwood City, California, was called in to complete construction of a multi-story retail location in Nashville, TN. A previous general contractor had begun the project by laying the cement slab and installing steel embed bolts. Project participants were concerned that errors made in embedding the steel bolts at grade had negatively impacted building of the steel structure above.

The Problem: Manual Inspection of Slab on Grade Point Cloud Confirmed Deviations

Because the SOG embed bolts and slab edges serve as the foundation for the structure, any improper location or alignment of these elements would have a spillover effect on the entire project, likely causing the vertical beams above to be installed out of tolerance as well. When DPR became involved, the designers feared improperly installed interior I-beams would cause expensive and timely delays in building the exterior skin of the structure.

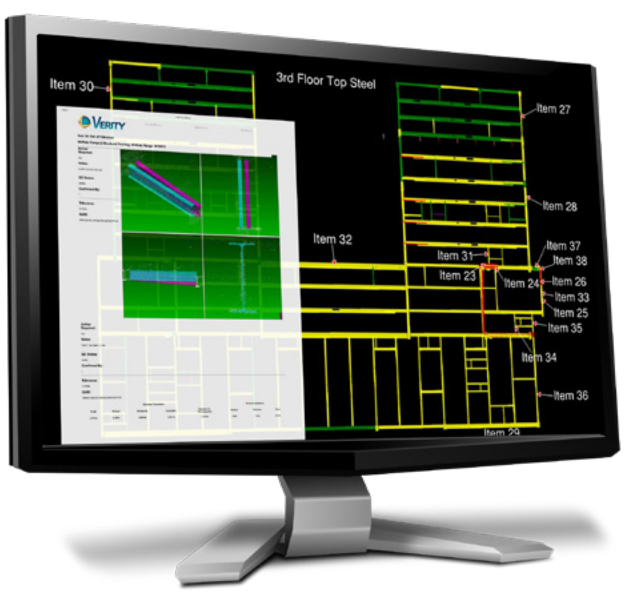
DPR obtained a 3D laser scan point cloud that had been captured after construction of the slab and embeds, but prior to erection of the steel. As is common practice, the point cloud was inspected manually in Navisworks and compared against the design model. In the 34 embeds evaluated, several mistakes were found: one embed was missing entirely, and two were out of place.

Verity generated a detailed HTML report as well as a color-coded model of the entire structure, which confirmed a deviation cascade from the ground up.

The Solution: Verity Automated QA Software

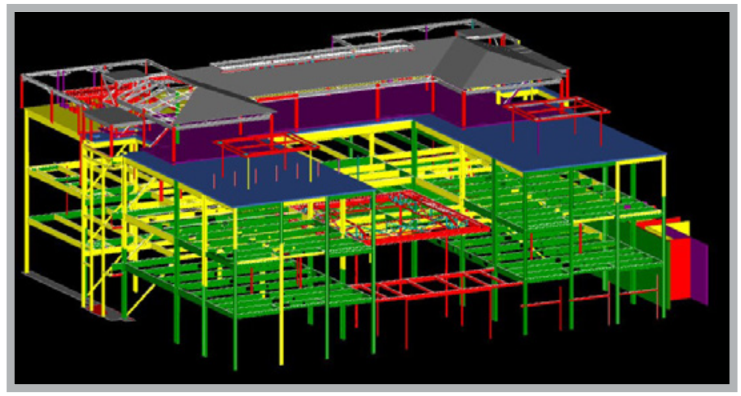
DPR had worked with ClearEdge3D as a beta tester for its new automated construction verification software called Verity and decided to deploy it on the Nashville project. Verity analyzes laser scan point clouds of recently constructed work and compares it against the design or fabrication models to determine the accuracy of the constructed elements. Out-of-tolerance work is highlighted including specific details on installation variances, rotation errors, twist and sag.

The Workflow: Laser Scan Point Cloud and Verity



Using a Trimble TX8 3D laser scanner, DPR captured 73 scans of the interior and exterior of the three-story building skeleton in five hours. After registering in Trimble RealWorks, the point cloud and design model were imported into Autodesk Navisworks which has deep data integration with Verity. From there, the model and point cloud were brought into Verity and analyzed by the software for deviations. DPR set Verity to inspect each of the 583 steel beams (mostly 20-foot-long I-beams) to a one-inch tolerance in x, y and z coordinate planes. Verity ran overnight and completed the analysis in eight hours, generating a detailed report showing variances for each steel member.

The Results: 50% of Steel Members Were Installed Out of Tolerance—45 Elements Flagged for Field Inspection



50 percent of the installed steel was out of tolerance, with numerous beams deviating substantially from the design intent. Verity generated a detailed HTML report as well as a color-coded model of the entire structure, which confirmed a deviation cascade from the ground up. There were 19 and 39 members out of tolerance on the first and second floors, respectively. Nearly all were out of tolerance on the third floor. The generated report allowed DPR to evaluate each steel beam individually to determine if the deviation required a field inspection. Forty-five were flagged because they were either missing or were so far out of tolerance they could potentially impact construction of the exterior building skin.

The Conclusion: Verity Substantially Reduced Risk of Schedule Delay by Identifying Problems Early in the Project

DPR sent crews to the site with 2D schematics to review the 45 flagged deviations. This information was also supplied to the designers to determine how to best remediate the problems prior to beginning the installation of exterior building skin. In addition, DPR ran the as-built model back through Navisworks to perform clash detection so field crews would be ready for future problems before they arise. Potentially major delays were avoided using Verity.

"Verity is a powerful new tool to help us understand what's really going on out in the field. Its tools to re-coordinate the true as-built are incredibly helpful. DPR is excited to use this technology on our future projects."

Tim Malys, Project Manager, DPR Construction

Chapter 6: Implementing Reality Capture Into the QA/QC Process

For firms already using laser scanners as part of their QA/QC process, utilizing a tool like Verity is a fairly simple prospect. You are basically inserting a companion tool into your workflow alongside tools you're already using, speeding up the current manual review process by up to a factor of 10. So, the value proposition and ROI are pretty easy to understand. You can either save by speeding up the review of critical elements and scope you're already checking, or expand what you're checking to further reduce your risk.

For firms that are just now thinking about taking the leap to using laser scanners, the implementation isn't quite so simple. You're basically changing up your current QA/QC workflows to incorporate several new tools and potentially new people and positions. To help, we've summed up a year's worth of learning from our current customers that are utilizing these tools in their QA/QC process to create this 10-step guide for incorporating reality capture into the general contractor's or subcontractor's QA/QC workflows.

Verity works on all scopes of work including MEP, steel, concrete, walls and more. Image courtesy of PrecisionPoint & Shiel Sexton.

10 Steps to Implementing Reality...

1. Understand what exactly you and your company want to accomplish and why.

What is driving your desire to change what you're doing? Schedule delays from rework? Unanticipated costs eating into your contingencies? Is it specific to just a few problem areas or the work in general? Knowing the problem you're trying to solve is crucial to solving it well.

2. Ensure "buy-in" all the way up the command chain.

There's no time like the present to ensure your new R&D project is aligned with the company's business objectives. If you know the problem you're trying to solve and what it is costing the company to leave it unsolved, building out an ROI for a change in technology and process is usually a pretty simple thing to do. Once you can answer the ROI question, it is time to take it up with your company's business leaders and get their endorsement—it will pay big dividends once it is time to put the pedal to the metal and implement across the company.

3. Be prepared to become the Champion-in-Chief for the new QA workflow.

No change occurs without a champion pushing it forward, and champions almost always come from the ranks of people most directly impacted by the problem. They're the most passionate about fixing it—and passion is a key ingredient for a champion. Don't look to someone from higher up to take up the mantle—if you've made it this far into a 10+ page whitepaper, you're probably the man or woman that is going to move it forward. Own it.

4. Pick a pilot project.

A lot of implementations go wrong by never starting—don't wait for the perfect project to test a new technology or process because they don't exist. Perfect projects are like unicorns: you'll still be waiting to see one 20 years from now. Instead, pick a job where the outcomes from the change you're testing will be useful (thus encouraging you and the project team to actually use it despite other pressures on your time), but not critical to the success of the job (so that if something goes wrong with the test, you aren't leaving the project team out to dry). This way you won't let the opportunity slip by, nor will you risk permanently damaging your company's view of a particular tool or technology because of a learning curve related mistake.

5. Choose a single scope of work on which to test software like Verity.

R&D projects are like real projects—most often killed by scope creep. Pick a meaningful scope of work on the pilot project like structure, cladding, or mechanical piping—something that is well suited to scanning and important for the project you're testing it on. Once you've got a win with one scope of work on one project, then you can think about hanging out with the scope creep and trying it out on a few more trades or projects.

...Capture Into Your QA/QC Workflow

6. Try before you buy.

Don't be afraid to ask for trials and demonstrations. Most software companies are happy to let you try out their software on a pilot project for free, and most hardware vendors are happy to send someone out to capture a part of your job site and register it for you for free as well. This is critical for finding the right solution cost-effectively as it lets you try out a few different pieces of software and hardware without a massive R&D budget at your disposal. Or, hire it out to an experienced consultant who is familiar with reality capture as a QA/QC tool for construction. You might be surprised to find that there are a lot of companies providing this service already and you can try it on for size without having to figure it all out in the process.

7. Choose the right tools for the right job.

So, I said pilot project, but I meant pilot projects. Choosing the right tool for the job is a critical step in any implementation, and the best way to do that is testing as many best-in-class tools as you can get your hands on to see which one works best for your company's workflows. This applies to both the software and the hardware you're using to facilitate this change. That way you can feel confident once it is time to pull out the company credit card that you're making the right choice. Too often this step is skipped and people just go for the lowest-priced option. Remember, you always get what you pay for.

8. Communicate findings to all stakeholders.

As you're working your way through pilot projects and other in-house testing, make sure to keep all interested parties around you up to date on the progress. Don't be afraid to share the mistakes along with the successes. Experimenting with new tools always leads to a few failures before you get it right and knock it out of the park, and the people running your business know that. Sometimes those failures and what you learn from them are the most important things to share. Communicating progress is how you maintain that buy-in you worked so hard to get earlier on.

9. Prepare a final report and present the business case to management.

Once all the numbers are in and you've got a good sense for the real value back to the company from making this change, you'll need to pull together a business case to show your company's leadership why it is worth investing in. If all went well, the report should confirm the ROI arguments you made earlier on, but with real dollar values assigned to them. At the end of the day, you're asking the company to reach into their pocketbook and spend money on this initiative instead of something that somebody else wants them to spend the same money on. So, you'll need to be prepared to show them why this is the one thing they should move forward with.

10. Put together a plan to spread the process throughout the company.

If you've made it this far then you've already written a check for the hardware and software. Now it is time to refine and teach the process to the rest of the company. The first and most important step towards doing that is to make an implementation plan. Failing to plan is planning to fail, so don't forget to take the time to put together a good roadmap. Plans should change over time as you learn more, but these plans are the guard-rails that will keep you on the road when you get distracted or fall asleep at the wheel. The plan will tell you what to do from here on out, so we'll leave it at that!

Chapter 7: Conclusion

Automated QA/QC Software Can Revolutionize the Industry's Approach to QA/QC

Verity and other new software QA/QC tools such as Rithm, Pericept, and SKUR are changing how installed work is validated and documented, ultimately reducing the inefficiency and waste inherent in current workflows. Leveraging reality capture technologies to thoroughly and completely document the job site, and then using that data as a basis for managing quality creates the opportunity to catch mistakes that would otherwise go unchecked in current workflows.

Further, by automating the first-pass at checking for mistakes using sophisticated computer vision algorithms, tools like Verity can accelerate the time to validate work by an order of magnitude or more. Verity provides a tool that allows both a complete and more detailed quality assessment of all the installed work within the same time it currently takes to spot check just 5% to 10% of the installed work.

While the industry cannot bite off all 450 billion dollars of this problem by installing software, these new tools provide a foundation to enable and encourage a number of workflow changes on the job site that can make a substantial dent in the billions wasted on rework each year. They are the first step in shifting the industry from a quality control centric process to one focused on quality assurance.

Tools like Verity can make accurate pre-fabrication a reality.
Image courtesy of Grunau Company, Inc.

3D coordination software, like Navisworks, created a fundamental process change where coordination moved from the drafter's computer and light-table to collaborative coordination meetings where all the trade partners work together to finalize a coordinated fabrication model of the building. Tools like Verity will have a similar impact on the process, creating the opportunity for collaborative quality assurance meetings where the same people will convene to review the installation of the work and quickly make decisions about how to manage discrepancies between the coordinated design and the as-built conditions. This will eventually eliminate emergencies from unknown installation errors and keep teams proactively working towards project completion. This alone has the potential to cut costs of rework in half over time.

As this process reaches maturity, it will pave the way for pre-fabrication and other advanced manufacturing techniques to thrive on the job site. Pre-fabrication and on-site additive and subtractive manufacturing rely on a high degree of confidence in whatever is installed prior, and this just isn't something that can be counted on today. As a result, these techniques are always partially implemented, and some amount of the pre-fabricated work is always modified in the field, or tossed out for site fabricated parts and pieces. This is done as a response to the discrepancies that tools like Verity can catch. If caught early, before fabrication begins, the fabrication models can instead be updated so that work can be completely pre-fabricated instead of just partially prefabricated.

These changes will take years to realize their full potential, but even the short-term gains from implementing construction QA/QC software make it well worth dipping your toes into using reality capture and tools like Verity.

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

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