AS125439

Reality Capture: Benefits, Workflows, and How to Get Started!

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Learning Objectives

- Understand the time and cost benefits of leveraging Reality Capture
- Understand the differences between various types of Reality Capture in the AEC industry
- Develop workflows to accurately integrate laser scans into Revit and improve Project Accuracy
- Implement appropriate Reality Capture Deliverables for the corresponding project use case

Description

This class will demonstrate various reality capture strategies and use cases in different architecture, engineering, and construction project phases. We'll focus both on strategies that can be implemented in-house as well as options for integrating outsourced deliverables into in-house workflows. We have integrated point clouds from laser scans and unmanned autonomous systems (UAS) photogrammetry, and we'll show our workflows and results. We'll talk about the setup process for attaining accurate shared coordinates for automated GPS placement within Revit software. We'll also demonstrate how we created and implemented affordable UAS photogrammetric scans into our Revit workflows, and how they compare to laser scan point clouds. This class will showcase several case study projects in which we used laser and photogrammetric scans for various needs, ranging from developing design concepts for small residential additions to new large-scale health care projects and multimillion-dollar departmental relocations inside existing facilities.

Speakers

Marin Pastar

Marin graduated from Drury University in 2005 and got licensed as an Architect in 2011. From the beginning of his career, he was deeply involved in 3D modeling and visualization with AutoCAD and 3DS Max, which evolved into a career-defining turn to Revit and BIM. Fascinated by BIM compared to traditional project delivery methods, Marin was the driving force in evolving the 11-person CAD firm into a growing, multi-office 100+ person VDC firm that Bates is today.
As Director of Innovation, Marin is involved in all aspects of Projects from Design and VR, to streamlining AEC Workflows from Planning and Construction, into Facility Management and Operation. Marin has been a regular AU attendee and a Revit Certified Professional since 2012. He has been invited to speak about VDC at several CSI and AGC conferences as well as AU 2015 and 2016. Autodesk recognized Bates as “Early Technology Adopters” and produced a customer success story published at https://www.youtube.com/watch?v=meJ2t3BSeR4

Aaron Gipperich

I have always leaned toward the technology side of Architecture. When the industry was transitioning to Revit, I went from leaning to diving in. In 2008, I was a driving force in successfully transitioning a 100 person Architectural firm to the Revit workflow. This was the start of the journey in BIM Management, and today I’m fortunate to manage the BIM systems for an architectural firm that doesn’t aim to push boundaries, but break through them entirely. From developing new Virtual Reality workflows to Integrated Project Delivery with Facilities Management deliverables. I am a Revit Certified Professional and have spoken at several AGC conferences on BIM Topics. As a regular presenter and steering committee member for the St. Louis Revit Users Group, I actively support the St. Louis Revit community across numerous disciplines.

Agenda

- Why use Reality Capture?
- How to get started?
- Different Reality Capture systems and technologies
- Reality Capture workflows & use cases
- Project Case Studies
- Q & A
About Bates
45+ Years of Experience
Veteran Owned Business

Locations
- Springfield, MO
- St. Louis, MO
- Rogers, AR

Resource Pool
- 100+ Architects & Designers
- 10 Administration

ENHANCED INTEGRATION:
Leveraging Technology and Innovation
to increase Transparency, reduce Duplication
of Effort, and Streamline Facility Management
and Operations
Why use Reality Capture?

Time & Cost Savings
- Gather more data faster than traditional field measuring
- Less time spent verifying = money saved
- Bigger the project scale, the better the savings & efficiency
- Renting scanning equipment is more affordable and easier to use than ever!

Better Accuracy
- Capable of +/- 1mm accuracy of existing conditions
- Capture data that is difficult to accurately verify otherwise (overhead systems, floor flatness, etc.)
- Objects are not “missed” during verification

Improved Project Transparency
- Stakeholders better understand what actual field conditions are
- Eliminate “silos” of analog verification from separate parties
- Reduced surprises during design

Improved Collaboration
- Verified data the entire Team can utilize simultaneously
- Data that can be merged with numerous software platforms
- Easily compare actual conditions vs. design intent with graphic data across disciplines
More Advanced Deliverables
- Plan linked 360 photos for Owner record data of MEPFP systems prior to walls and ceilings getting “closed up”
- Improved Construction progress and logistics tracking
- More accurate as-built model deliverables

How to get started?

Identify the needs:

Existing Conditions
- Basic capture - verify “what’s there” via traditional and 360 photos (non-measurable data)
- Accurate building exterior & interior scans
- MEPFP systems
- Site conditions
- Sub-grade utilities via Ground Penetrating Radar
Construction Coordination
- Systems routing and clearances
- Clash detection of existing vs. new
- Coordination with non-modeled existing conditions such as floor flatness, hangars, kickers, etc.

Construction Inspection & Verification
- Track overall site progress quickly via drone scan
- 3D model and photo verification
- Drone video footage
- Keep the AEC Team and Client informed

Project Visualization
- Generate models of large project sites via drone scan for master planning
- Existing conditions model scans merged with new design models
- Time lapse and sequencing animations merged with scan data or video
Facilities Management
- Plan linked 360 photos for Owner record data of MEPFP systems prior to walls and ceilings getting “closed up”
- Improved Construction progress and logistics tracking
- More accurate as-built model deliverables

Project Scale
- Size of project will determine appropriate method of capture
- Multiple scanning methods may be used on same project for specific use cases
  - Drone aerial scans for overall site study and verification
  - Static Photogrammetry scans for visualization and basic verification
  - Hi definition LiDAR scans for high-accuracy applications

In-House or Outsource?
- Certain applications can easily be accomplished in-house with minimal equipment and training
  - Drone aerial scanning is simple and can be done with minimal investment
  - Photogrammetry scans with tripod based systems
  - 360 photo capture
- Tripod-based LiDAR systems are expensive and require extensive training. Procure this service from qualified professionals.
- Handheld and backpack LiDAR systems can be rented for a reasonable fee and self-performed.
Reality Capture Systems and Technologies

Cost vs. Accuracy

- As often the case, better accuracy costs more $$. This is certainly true with reality capture. Costs compile both in equipment costs and time spent on site acquiring capture.
- At the low end, accuracy may be within a tolerance of +/- 6” (basic aerial drone scan). This scan may capture dozens of acres in several hours.
- For maximum accuracy (+/- 1mm), the equipment can cost over $50K and take multiple days to scan 100,000 SF of interior space.
- There are numerous levels in between these two extremes.
360 Photo Capture

- Inexpensive and simple to use. Press a button!
- Outputs JPG image files
- View photos in free 360 photo viewers that “stitch” the JPG
- Cannot extract measurements from 360 photos
Photogrammetry

- Photogrammetry technology stitches multiple camera images together in software to create a 3D mesh or point cloud file
- Tripod solutions can provide excellent visual graphics
- Accuracy is limited even on the best systems
- Budget friendly. A quality drone can be less than $1500. Tripod based solutions are under $5K.
- Excellent option for strong visuals where accuracy is not a high priority

Matterport Scanner

- Budget Friendly
- Great Visuals, VR
- Web Based Viewing
- VR Capability
- Limited Accuracy
  - +/- 2” over 10’
Photogrammetry – Drone Capture

Drones capture hundreds or even thousands of images during flight then process in the cloud to generate a point cloud or mesh model. Flight is pre-programmed and autonomous with mobile apps such as DroneDeploy.

There are numerous platforms for processing the images. All operate via cloud processing.
Note: Drones over 0.55lbs require FAA registration. Users should acquire FAA 107 registration (UAV Pilot license) for commercial purposes. It’s good stewardship and could save your bacon!
LiDAR (Light Detection and Ranging)

LiDAR (also called LIDAR, Lidar, and LADAR) is a surveying method that measures distance to a target by illuminating that target with a pulsed laser light, and measuring the reflected pulses with a sensor. Differences in laser return times and wavelengths can then be used to make digital 3D-representations of the target.

- Extreme accuracy is capable with LiDAR (+/- 1mm)
- Tripod solutions provide the most accurate results, and can deliver 360 camera views from each scan location that include measurement capability. Tripod based systems have a high learning curve and are best procured from a professional scanning service. Not recommended to rent and self-perform unless you have experience.
- LiDAR scans can be registered to real-world geospatial coordinates
- LiDAR equipment is expensive. Starts at $15K.
- Available in tripod (static) and mobile solutions. Mobile solutions are less accurate than static, but still offer much greater accuracy than photogrammetry systems.
- Backpack and mobile cart solutions can scan expansive square footage per day. Backpack options are great for occupied spaces for minimal intrusion.
Aerial Scanning - Stormbee + Faro

Mobile Cart

Trimble TIMMS

Handheld/Backpack

Indoor Reality

GeoSLAM Zeb-Revo

Leica Pegasus
Project Workflows

Establish Real World Coordinates

Aligning your Revit models and CAD files to true, geospatial coordinates helps tremendously with aligning point clouds. We recommend aligning your models prior to acquiring LiDAR laser scans when possible for this reason. When using static LiDAR based scanning equipment, they can be registered to match the coordinates of your models. This allows for correct alignment of the point cloud in the Revit environment via Shared Coordinates.

Not all reality capture systems can utilize accurate geospatial information, particularly Photogrammetry based scanners and some handheld LiDAR devices to not register. None the less, real world coordinates have benefits to the project team beyond scanning.
Modeling Existing Conditions in Revit

With a point cloud linked into your Revit model, it’s simple to align your existing conditions geometry to their true spatial location. Point clouds are visible in all model generated views.

When correctly registered to geospatial coordinates, point clouds should come in automatically in the correct location when linked via Shared Coordinates. If your project does not have geospatial coordinates set up, point clouds can be manually placed. Identify a 0,0 starting point for alignment and work from there. Pin the point cloud to avoid accidental movement.

Simple Tips in Revit:

- For floor plans, set the bottom of your view range to be several inches above the level. This will eliminate the points on the floor from the view and will read much cleaner.
- For sections and elevations, make the view depth very shallow (12” roughly) to clean up point cloud data beyond. Like the plan view, it makes the view cleaner.

Viewing Point Clouds in C4R models

Revit models hosted to the C4R cloud can view point clouds, but since point clouds cannot be loaded to C4R they must be saved locally. Having a separate model just for hosting the point cloud works well as that model can be linked into other Revit models for verification. This eliminates the need to host point clouds in the native working model. We’ve found the simplest workflow is to have a separate cloud Revit model for each party that wants to use the point cloud, and each party hosts
the point cloud data locally. When possible, save point clouds to local C: drives for all users who need access. Point clouds are massive files and will slow your network bandwidth.

**Viewing Point Clouds in C4R**

- Establish a Revit model on C4R for each party requiring point cloud access.
- Each party has a local copy of the point cloud into their C4R model
- Point Cloud model can be linked into other models for verification & modification.

![Image of C4R interface](image)

**Visual Coordination in Navisworks**

Point Clouds can also appear in Navisworks for coordination purposes. The simplest approach is basic visual coordination. Use this in areas where anticipated conflicts may occur. Point clouds may also be used within clash detection routines, but this involves extensive setup for best results.

![Image of Navisworks interface](image)
Scan Regions in Autodesk ReCap

Recap is a powerful tool for point cloud viewing and manipulation. If you are working with point clouds, learn to use ReCap. It’s a very simple software that takes minimal time to learn the basics.

Establishing regions within Recap is an excellent method to bring in cleaner point cloud data with better control to your Revit models.

2 minute tutorial on using Regions in ReCap:

Conceptual Design – ReCap Photo to Infraworks

ReCap Photo has a powerful cloud-based processor for creating point cloud and mesh data from drone imagery. The processed quality has shown to be very favorable compared to competing platforms. Note that ReCap Photo does require the use of Autodesk Cloud Credits for processing the scans.

Autodesk Infraworks can merge the processed mesh or point cloud data from ReCap photo into a geospatially correct location to perform conceptual site modeling. Infraworks is a powerful tool for master-planning level design and visualization.
Project Case Studies

Mercy Northwest Arkansas Hospital Expansion

Bates commissioned LiDAR scanning of the existing hospital exterior and the interior of the CEP (Central Energy Plant). This data was extremely valuable for updating our Revit model to the actual field conditions of the building footprint. The CEP scan allowed the MEP team to model equipment accurately for the new work connections. Construction coordination with the extensive piping system was performed.

Building Exterior scan:

Central Energy Plan interior scan:
Early in the project, when the laser scan was inserted via shared coordinates into our geospatially correct model, there was a minor discrepancy in its location. At the time, we ignored the discrepancy and assumed it must be a minor error between the reality capture system and the civil points. We manually aligned the point cloud to a known building corner and worked from there.

Fast forward several months, it was discovered that the point cloud was indeed correct, and the building footprint was incorrectly placed by several inches. After correctly aligning the building footprint, the point cloud’s original location proved to be accurate. Lesson learned…trust the data.
Mercy Hospital Springfield Additions and Renovations

The Project Team has utilized LiDAR interior scans after demolition to verify the existing interior conditions. These conditions were updated in the Revit design models for enhanced accuracy and coordination.

The point clouds are also used for Construction Coordination purpose of the above-ceiling systems (Not actual image from this project).
Early in the project we discovered the importance of registering the point clouds in the proper units. The first point clouds received were registered with U.S. Survey Feet units, which Revit does not support. This caused the point cloud to incorrectly locate by approximately 16”. When re-registered with International Feet Units, the point cloud aligned correctly.

Location after registering to International Feet.
Private Residence Addition

Drone Scanning was used to design an addition to a private residence. A Revit design model of the existing residence was created from the linked point cloud data. From there, several design options were created in Revit to produce the final design. This method provided faster verification of the existing site with visuals that stunned the client.
Boutique Hotel Addition

For the design of Phase 2 of the award-winning Vandivort Hotel in Springfield, Missouri, Bates integrated drone video footage with design animation to create a stunning effect of the client’s building rising from what is now a parking lot.

The combination of live video with 3D animation provided a stunning visual effect that truly excited the client.