How Reality Capture is Changing the Design and Construction Industry

7 Ways Reality Capture Can Help You Deliver Your Projects with More Accuracy and Efficiency

AUTODESK

Contents

The State of Documentation and Surveying Today

Current Practices

The current practice for capturing existing field conditions is a tedious, manual, often analog and inaccurate process, which leads to costly rework. Whether a building renovation or large-scale infrastructure project, the surveying and documentation process looks something like this:

1. Start with a static raster image of a very old blueprint and trace it into a CAD format so that it becomes editable.

2. Visit the site to verify that existing conditions on the ground match the blueprint. Measuring with a distance meter or tape measure, capture any changes or inconsistencies with the existing plans.

3. Find a way to capture complex, hard-to-measure objects and details like exposed piping, that cannot be accurately captured in a simple, efficient way.

Not only is this a time-consuming and manual process, but also an inefficient one, where you may be left with sections of the site that you were not able to measure accurately.

Accuracy Limitations

Traditional surveying methods are not always reliable. Some inefficiencies include:

- Limitations in accuracy and coverage of data points from traditional surveying methods.

- Older CAD drawings or 3D models, which are often inaccurate, inadequate sources of as-built data.

- Inconsistent survey data which requires additional surveys over the course of the project.

Costly Services

While complicated projects may turn cost-prohibitive, the average project must still budget and pay for:

- Cost of professional survey specialists.

- Unforeseen cost add-ons from multiple return trips due to missed or inconsistent measurements.

- Cost overruns from rework due to insufficient capture of complex existing conditions.

Despite such tedious verification work, you end up with an inaccurate and incomplete starting point for design. With a poorly set stage, it's no surprise that projects often run into delays, design and construction rework, and costly change orders.

How Big is the Problem Really?

An increasing amount of non-residential buildings and infrastructure currently or will soon need major repair.

Government data sources in the US estimate that about 80% of non-residential buildings are more than 20 years old. The need to renovate these buildings is growing in demand and will only increase as time goes on. A majority of non-residential buildings in the UK were constructed before 1980, with educational, health, and gastronomy buildings making up the largest share.[1]

Infrastructure follows closely behind, with much of it in the US failing due to age and lack of maintenance.[2] Many projects are over 50 years old, but were only designed for a lifespan of 50 years.[3]

In the UK, 70% of transportation infrastructure is over 100 years old. In preparation for this, the UK has planned £425 billions through 2021..[4] The German Institute of Urban Affairs has estimated that 15% of Germany's municipal road bridges need to be completely rebuilt.[5]

To compound matters, these projects were designed before the age of digital documentation and may only exist in 2D physical blueprints, if at all. You are almost guaranteed to start a project on an older structure with static image documentation of the existing conditions. Trying to check and update those old blueprints manually is extremely difficult and time-consuming and you need to be prepared to work on these projects with an alternative and better approach.

Furthermore, as you move into design, implementing BIM (Building Information Modelling) workflows on renovation projects becomes a much bigger challenge than originally thought without an easy onramp into a 3D environment. Design and construction firms in the AEC industry not already deploying BIM will be impacted by standardized processes, technological improvements and mandates as BIM adoption grows worldwide.

80% of non-residential buildings are more than 20 years old
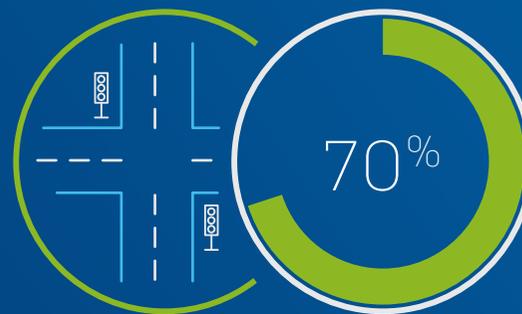
In the UK, 70% of the infrastructure in projects are over 100 years old

15% of Germany's municipal road bridges need to be completely rebuilt

An Introduction to Reality Capture

There is a better way to capture existing site conditions accurately and completely, in both building renovation and infrastructure projects. Implementing a digital Reality Capture process enables you to minimize labor requirements, save time, and reduce project risk. The result is a highly-accurate, full-coverage, actionable set of real-time data, which can be directly connected into 2D and 3D design processes.

Reality Capture is the process of producing a digital 3D model representation of your object, building or site created by scanning it in the real world using static, mobile and aerial laser scanning and/or photogrammetry.

With either laser scanning or photogrammetry methods, millions of surface points are measured and mapped to develop a textured, high-resolution, geometrically precise 3D model.

The Reality Capture Process can be defined by 3 Key Steps:
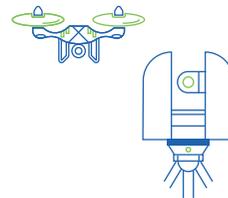
1. Capture

Using hardware such as laser scanners or camera-mounted UAVs, a site is scanned and a detailed set of data or "points" is captured for further processing.

2. Compute

Using Reality Capture software, scan data is automatically registered, stitched into a coordinate system, cleaned up, and analyzed. The final product is a point cloud or mesh ready for CAD and BIM authoring tools.
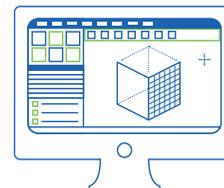
3. Create

Design with confidence knowing that your base information is a model of up-to-date data of actual site conditions, whether on a building renovation or large scale infrastructure project.

Scan with Accuracy, Design with Confidence

Having a comprehensive scan of the entire site can help you detect issues earlier than traditional surveying methods and often give an "under the hood" or "up close" insight into potential problems you may run into. Issues that can cause serious rework or halts in a project's timeline include:

- Structural issues like bowing, buckling, or deflection.

- Thermal changes to the site or structure from freezing or thawing during seasonal changes.

- Effects of façade treatment on environmental quality of a building's interior.

- Incorrect installation of mechanical, electrical, plumbing and other complex building systems.

- Geotechnical or topographic issues.

- Inaccurate mapping of utility placements or other hidden site elements.

- Inability to measure earthwork and site changes over time.

See Beyond the Site

Once scan data is aligned to a 3D model, the benefits of Reality Capture extend into the design and construction phases. Architects **gain a clear understanding of site restrictions and challenges** which allows them to overcome these through creative design. Engineers can **be better prepared to handle problems at an earlier stage of the project.** All stakeholders can leverage the data and digital model to **make better decisions** like designing an optimum layout based on topography or using materials that reduce energy costs.

Begin with the End in Mind

No longer do architects, engineers and site surveyors need to take multiple trips to the job site to capture and verify existing conditions. Using Reality Capture, your teams can **scan once and design with confidence** knowing that the conditions data they are designing with is **accurate, detailed and actionable**.

# 7 Ways Reality Capture is Changing the Design and Construction Industry

The Glen Canyon Dam is one of the largest concrete arch dams in the world. It is essential to the infrastructure of a region that can be adversely hit by drought and storm alike, but is well over 50 years of age. "Its engineers believe that the concrete would withstand use for several thousand years."[6]

But still, the Glen Canyon Dam is no exception to risky factors that affect its safe operation. In addition to siltation, spillway collapse, and abutment failure, the Bureau of Reclamation is hastening its response to anticipated extreme weather fluctuations due to climate change. The risk for cracks or overflows during flash flooding only increases with time.

With powerful Reality Capture technology, the Bureau of Reclamation has been able to quickly scan the exterior and interior of the dam to bring it into the digital age, which will help them assess and address structural risks. Not only will facility managers be able to measure change over time but also ensure inspections are done safely with minimal personnel presence.

Massive, complex, and crucial public projects are not the only place Reality Capture is changing the way things are done. Architects, engineers, and surveyors worldwide are using Reality Capture to deliver projects more efficiently by delivering as-built drawings in BIM, allowing increased interactivity with existing conditions and the capture and verification of site progress during construction.

From building renovations to infrastructure development, Reality Capture's applications extend to every step of the build process. It is quickly becoming an integral part of the studio and jobsite because it helps teams start, sustain, and deliver complex projects.
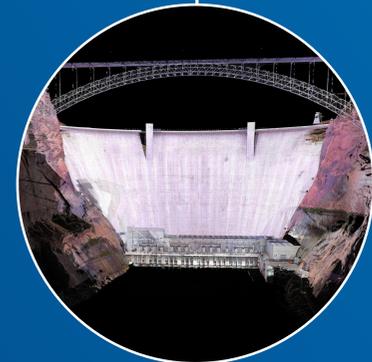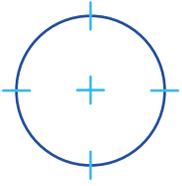
1. Accuracy is Everything

No more wrangling with out-of-date 2D blueprints or fussing with tape and distance meters at site visits to validate existing conditions. No more return trips to double or triple check measurements. With photo-to-point cloud creation or laser scanning, you can gather millions of points simply by taking photos with a camera-equipped unmanned aerial vehicle (UAV), hand-held device, or laser scanning device. You can combine this captured data from both sources, if needed. Reported accuracy for most terrestrial laser scanners currently in market is 3 mm.[7] With the ability to take such exact measurements, your projects and sites, large or small, can be captured with an **amazing level of detail**.

This scanned data is actionable combined with a digitized 3D model in the software of your choice. Each point captured is mapped onto an XYZ coordinate system, providing a **more intelligent survey output to export for use**.

Rework is eliminated, because scanning technology uses information from hundreds of photos or scanned points within seconds of capture time. You can accurately pinpoint buried or hidden infrastructure if it's captured during installation, preventing unnecessary revisions later.

You won't have to go back to the site to remeasure and double check the initial survey measurements. Just place your laser scanner on a tripod or set a UAV with LiDAR scanner on a defined flight pattern. The technology takes over from there to create a **superior 3D model with millions of scanned data points and laser accuracy from the first site visit.**

> You can measure the model, view and analyze data in elevation maps, organize and clean up regions within the point cloud, create a mesh, and manipulate the model.

2. Built-in Efficiencies

WeWork is a fast-growing company whose business model centers around renovating existing buildings into beautiful office spaces to rent out to small teams and entrepreneurs, one desk or space at a time. Having an efficient renovation process is key to their success, so they start every single renovation project by scanning the existing conditions to ensure they have the most accurate data to design from. They do this because, "**design intent won't be the build intent without scanning**". In other words, the Reality Capture process helps ensure that the resulting construction of every WeWork office space is an accurate execution of the design vision.

The simplicity of the scanning process also **significantly reduces the labor costs spent on surveying and documentation**. You can capture billions of points as opposed to tens or hundreds from traditional processes. This galvanizes your ability to access and manipulate as-built data, making workflow transitions into design authoring and simulation more seamless.

Whether scanning a site yourself, like WeWork, or using a survey specialist to complete a site scan for your team, either approach will **save you hours at the jobsite**. With these built-in efficiencies, Reality Capture eases responsibilities on staff by reducing manual work and slashing the time and effort it takes to capture existing conditions.

Architecture Building & Design

Customer Spotlight

Bates Architecture

" I estimate approximately a 50% reduction in cost by using 3D laser scanning vs. trying to capture all the same information with a traditional 2D surveyor. The biggest savings was the time savings – this was probably the shortest time frame project of the largest scope which Reality Capture helped us deliver. "

Marin Pastar
Bates' Director of Innovations

When tasked with making major improvements to Mercy Hospital in Missouri, Bates Architecture started off the project with Reality Capture. They scanned the structure inside and out to understand site conditions and model design intent. With a 3D point cloud created in just a few minutes, this workflow resulted in significant efficiencies in both time and cost savings.
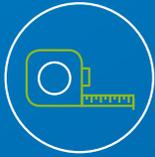
3. Less Manual Work and Trips to the Jobsite

Reality Capture removes the need for tedious manual capture of site conditions and gives your team confidence that the data they capture on-site is **accurate, up-to-date, and comprehensive.** Not only that, **scan data contains complete coverage of 'every point' you'll ever need**. This eliminates the need for unnecessary return trips to the site to remeasure, verify, and augment captured conditions or out-of-date site plans.

> Instead of time wasted on return trips and repeatedly scanning a site, you can deliver full site scans in intelligent, digitized formats in a matter of days instead of weeks, and move onto the next project.

Surveyors, contractors, and designers alike can **focus on leveraging these new efficiencies in their workflow**, reducing project schedules by allowing teams to "**capture once.**" Survey specialists, armed with digitized data that provides deep insight, can now add more value to the project by pointing out opportunities or potential conflicts that the design and construction teams may encounter later. Additionally, surveyors can take on more work because of these new efficiencies due to Reality Capture.

Design and construction firms can also invest in their own Reality Capture technology at affordable prices. This allows them to provide for their own site documentation and surveying solutions when needed, especially if required at short notice.

If we've seen anything in the digital revolution of our time, it is that **small devices can be powerful and disruptive**. In the AEC industry, the use of these devices **mitigates risk and increases safety of personnel, especially when surveying hard-to-reach areas.** With fewer surveyors on site and reduced need for personnel to access unsafe, inaccessible areas, there is **improved safety and lesser risk to the project team overall.**

Civil Infrastructure

Customer Spotlight

Crafton Tull and Associates

" By using the Reality Capture workflow to capture existing conditions, we save time in the field and man hours. In addition to the point cloud, having the georeferenced image of existing conditions is extremely important. It helps us make decisions quicker and provide our clients multiple design options. "

Brad Unruh
Crafton Tull and Associates

4. Start Designing in 3D

Reality Capture is the bridge between existing site conditions and an intelligent BIM environment. As design and construction projects implement the BIM process, teams have quickly realized the benefits of designing in 3D, which include a reduction in design and documentation rework and the shortening of design and construction schedules by as much as 40% and 30%, respectively.

Reality Capture **jump-starts project delivery by starting with a 3D site representation as soon as the scan begins.** Real world conditions and context are reflected with LiDAR and photogrammetry, and is directly mapped into the model as a dimensionally accurate point cloud or mesh.

Scan-to-BIM as a process for the AEC industry is becoming widespread. In the most commonly used two-step process, Scan-to-BIM begins with scanning by using devices that capture points with XYZ coordinates. This collection of points is called a "point cloud", and can be easily converted into a BIM model with the help of processing software. Regions of points can be labeled as components or features, like "window" or "piping."

With adequate training and software, this becomes a quick process. Software and hardware improvements are rapidly being made in the industry, which will further integrate and simplify this process.

Customer Spotlight

Turner Fleischer

Companies like Turner Fleischer have seen huge success in adopting Reality Capture to design right away in 3D. In one project example, they used the existing conditions as a basis for their design, starting immediately in a 3D environment. They also were able to avoid any potential issues or change orders down the line by creating their design and model around the existing conditions.

On one project alone, they estimated a 325% ROI by implementing Reality Capture.

325%

Turner Fleischer reached a 325% ROI for capturing as-built conditions directly in 3D and designing around them.

5. A More Interactive Process

Through implementation of software tools, Reality Capture becomes a collaborative process, not just a simple documentation process. In a digital environment, point cloud data becomes immediately usable—you can take notes, capture stakeholder feedback, measure existing site conditions, and more. With these Reality Capture tools—many of them cloud-connected—the process becomes interactive and collaborative, which allows you to do more with captured point cloud data than ever before.

When the reality data is uploaded to the cloud, it becomes **ready to manipulate in real time, enabling immediate stakeholder interaction, which in turn hastens decision-making.**

Designers and stakeholders can see and manipulate a real-world view of their building or site, facilitating speedier engagement.

6. Better Construction Verification

Documenting progress at an active construction site is a difficult process and, if done inaccurately, can lead to significant problems. Teams are always attempting to ensure construction accuracy against design intent and the need to create final as-built documentation before project handover. Liability, schedule, risk, and safety concerns are all top of mind for teams managing projects in the field.

Reality Capture is the best way to document the construction process on-site because it **provides immediate visual information and is extremely accurate**. Using up-to-date scan data of a site ensures that you can go back during installation and know exact dimensions of the space at any point in time as the project progresses.

The scanning process makes it easy to take continual scans for comparison purposes and visual logs, which in turn can act as regular progress updates for the team. By comparing the design intent to the as-built snapshot, contractors can **monitor installations and catch discrepancies early on**, avoiding issues down the road. You can perfectly capture a moment in time and review it against its previous state. This way, you can deliver high value as-built models and verifications at project handover.

As noted in a case study[8] written by Carnegie Mellon University researchers, many construction defects happen during the building process. Technology like Reality Capture that allows you to pull more thorough site data can help prevent this and save on costly rework.

> 66 We can scan multiple times over the course of the project instead of just preconstruction. Scanning is the only way to capture that breadth of information. You can't do it any other way. 99
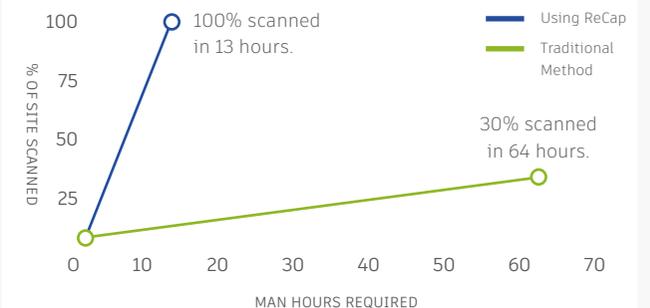
Thad Wester
WeWork

Chart — % OF SITE SCANNED vs MAN HOURS REQUIRED:
- Using ReCap: 100% scanned in 13 hours.
- Traditional Method: 30% scanned in 64 hours.

7. Ease of Use

As both hardware and software technology matures, Reality Capture is no longer a process reserved only for specialists. Previously, it took expensive equipment operated by highly-trained technical staff to get basic Reality Capture data of a site. Now, it is completed in a fraction of the time with only basic training (and certification to operate UAVs) needed.

Laser scanning hardware now offers "push-button" simplicity and UAV flights can be automated with simple flight path planning tools via mobile devices in the field. The registration of scans and stitching of photos is now an automated process thanks to the advancement in Reality Capture software. **Going from site to a digital model is simpler and more cost effective than ever before.**

Implementing easy-to-use software tools turns Reality Capture point clouds and photos into immediately-actionable data. Rather than a series of manual measurements captured by hand on site, **Reality Capture data can be manipulated, analyzed, and prepared for use in CAD and BIM modeling tools for further design.** End-to-end workflows automate manual processing of data, giving your team more time to work on creative, non-repetitive designing and problem-solving tasks.
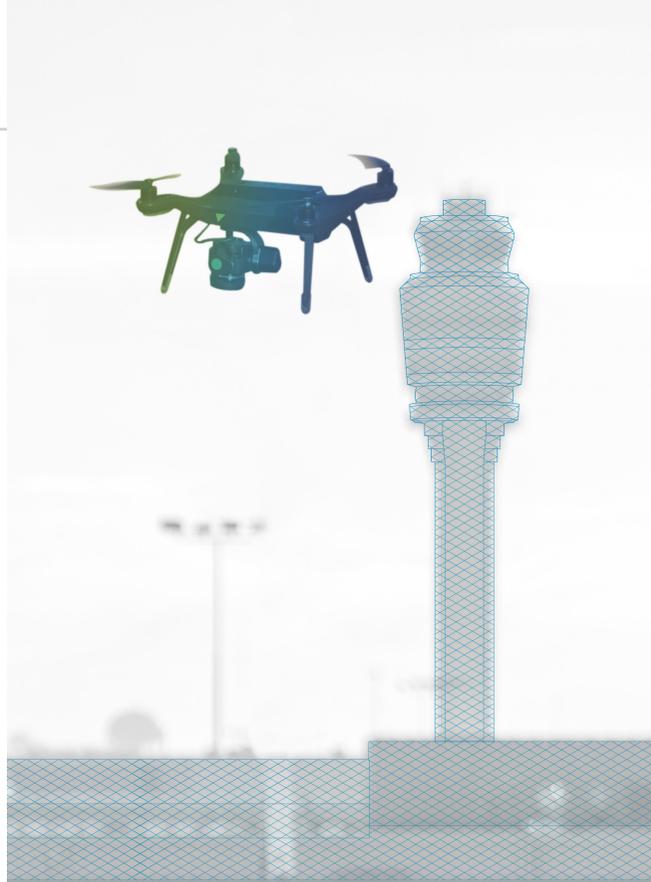
This democratization of the Reality Capture process is leading to wide adoption amongst design, engineering, and survey companies who are realizing the benefits of Reality Capture, while bypassing the technical hurdles of past decades.

Civil Infrastructure

Customer Spotlight

Strathcona County

Strathcona County is working with and educating consultants on how to use Reality Capture to their mutual benefit. Their consultants were easily able to bring point clouds into Autodesk modeling software to perform measurements and feature extraction. The County is now working on a major roadway upgrade and was able to take detailed scans from several intersections with a push of a button and in a fraction of the time it would have taken with traditional methods. The scans were so detailed, **local business owners could easily visualize the impacts to their property.** The scan also allowed for feature extraction of the power poles down the roadway. The County had access to the data of what exactly is already there, without having to manually survey, which would have taken exponentially more time. And, **data of existing buried public utilities could be added within the digital model easily and intuitively.**[9]
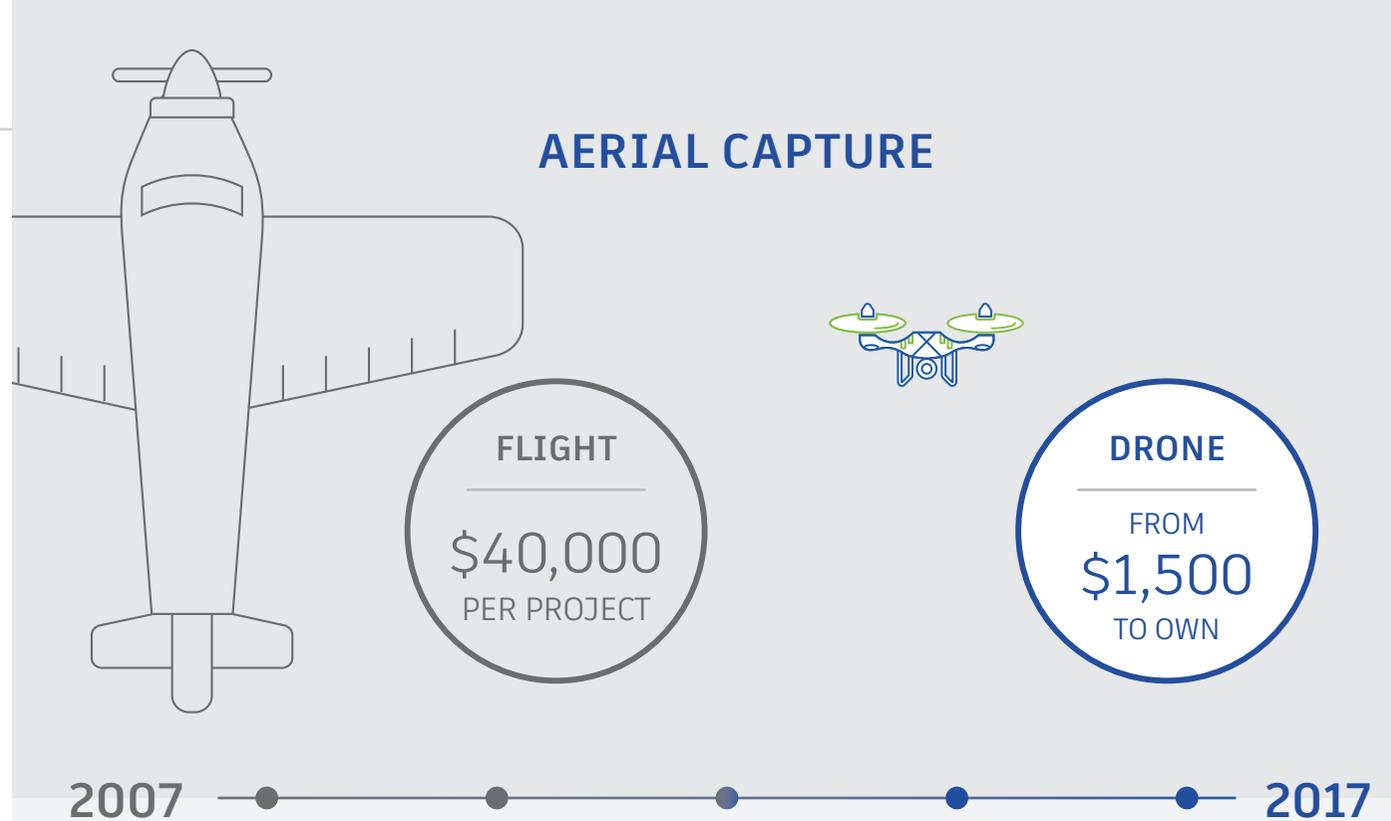
What is Driving Adoption for Reality Capture?

Reduced Barriers to Entry: Device and Hardware Trends

There have been significant advancements in laser scanning hardware that continue to make it easier and easier to adopt the Reality Capture process. To illustrate how far scanning hardware has come in the past 10 years, let's compare equipment from 2007 to today. In 2007, scanners were upwards of $80,000 each, and so heavy you needed a team of people to lug them around. Fast forward to today, hardware and software partners are launching a newer, lightweight scanner, and software packages that have increased functionality, at a fraction of the price. These devices are so light and small that anyone could slip them in a backpack, go to a site, start scanning, and immediately begin processing scan data using mobile software.

Similarly, in the realm of UAVs, the cost of scanning a site has dramatically reduced. Where it once took $40,000 to do a one-time scan of a site from a professional service company or LiDAR-equipped plane, you can now own a commercial drone starting at $1,500 and start flying a site on-demand.

AERIAL CAPTURE

FLIGHT

$40,000
PER PROJECT

DRONE

FROM
$1,500
TO OWN

2007 ———————————————— 2017

GROUND CAPTURE

LiDAR

$80,000
TO OWN

24 lbs

BLK360

$16,000
TO OWN

2 lbs

*Illustrations not to scale

Intuitive and Integrated Software

Photogrammetry and laser scanning software solutions have expanded greatly in the past several years. For the design and construction industry, a true Scan-to-BIM workflow will get you from push-button scan to deployable BIM model in a few hours. With no previous experience, any industry professional can navigate the workflow because of how user-friendly and intuitive it has become. One-click automated processes perform powerful tasks like auto scan registration, which stitch multiple scans into a single point cloud, and intelligent cleanup services, which automatically remove unwanted noise, but still allow for automatic feature extraction.

Perhaps most importantly, the software now integrates directly with key CAD and BIM design creation tools so you can bring reality data into the data creation tool of your choice, including AutoCAD, Revit, Navisworks, Civil3D, InfraWorks, and others. Reality Capture allows you to enhance intelligent models built from existing data with captured elements, such as a roadway section or a building interior, and bring it into design modeling software as point cloud data. You can then easily process the point cloud data to generate surfaces or perform an analysis of your project by applying classification themes for your project, like intensity and elevation.

Once the existing conditions have been recorded, you can conduct a preliminary design layout for your project, whether it be an HVAC layout within an existing building renovation or setting roadway alignments on a transportation infrastructure project. In addition, generating your design within the real-world context of the project's existing environment allows you to more effectively communicate design intent with project stakeholders and the general public.

Extensibility into Mobile Apps is Crucial

Reality Capture is most used in the field, so enabling field crews to use handheld mobile devices is paramount. The point cloud data can be viewed, marked-up, and shared from a tablet to the office with notes and annotations in real time. You can register scans in real time in the field. Questions and clarifications from team members can be answered and resolved quickly. During construction, comparison analysis can be done on the spot, instead of having to wait for the data to be brought back to the office, analyzed, and then sent back to the field.
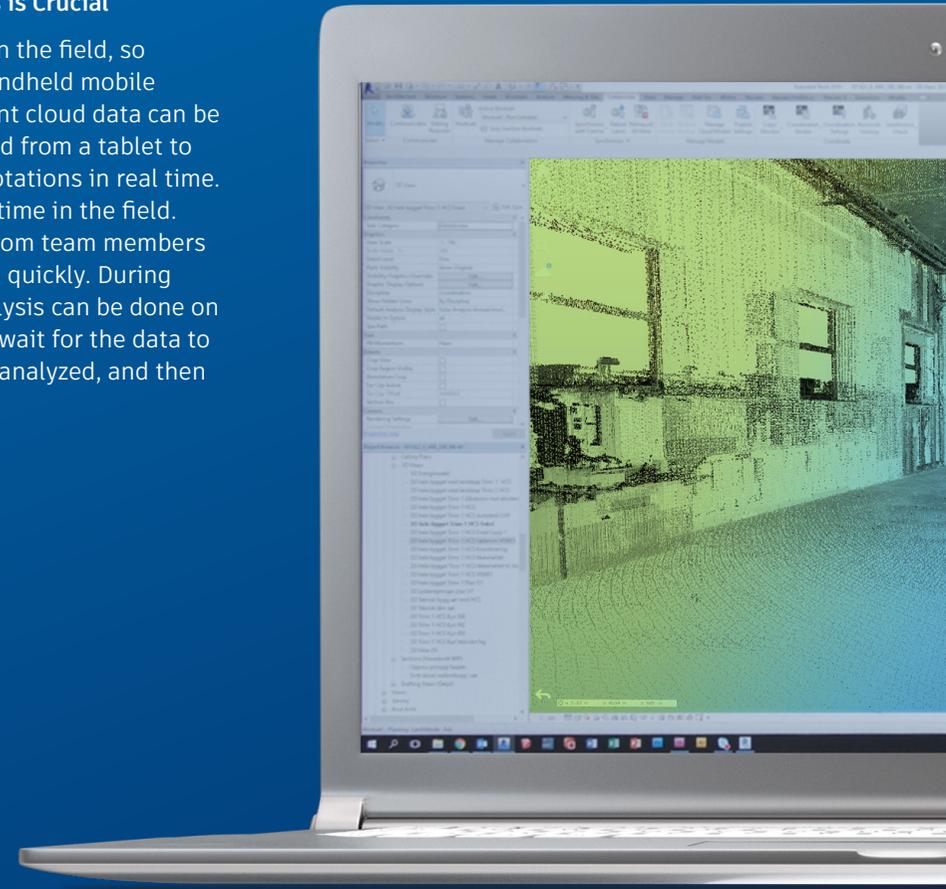
Capture the Present, Form the Future

Reality Capture helps you quickly create 3D models of site conditions to ensure timely project delivery, while improving **productivity, accuracy, quality, and safety** throughout the design and build process.

You can **bring your projects into 3D environments instantly,** from building renovations to large infrastructure projects and everything in between. By closely monitoring construction progress and working on the most accurate 3D representation of a site, you can **greatly reduce the number of change order requests and rework.** This helps you **stay on schedule and win more projects** because you can ensure design excellence and timely delivery. As a **robust quality control tool**, Reality Capture allows you to **prevent small mistakes from becoming disasters or predict them before they even occur.** Finally, Reality Capture is **accessible to any skill level.** With **increased accessibility, affordable hardware, and powerful, intuitive software,** it is easier to put Reality Capture into practice on your jobsite or design workflow now more than ever.

Get Started Today

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