AUTODESK UNIVERSITY 2013

Recap of Laser Scanning: Existing and Historic Structures with New Design

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This class provides an in-depth discussion of best practices for using laser scanning in building a design with existing and historic structures. As more projects are designed in 3D from the beginning, architectural, structural, and MEP are faced with the challenge of dealing with existing structures. We address the how and why of laser scanning, which is an ideal choice for documenting these structures. This class discusses laser scanning by reviewing several project case studies. The first project is the $135-million new renovation of the 1926 San Antonio Performing Arts building. Three other projects include a parking garage, a new office space remodel, and new loft apartments, each of which is going into buildings that are over 100 years old and for which there is no as-built information. It will also show a half century old working hospital where over one million square feet were scanned and address the challenges of laser data on large projects. This class also highlights the use of Autodesk® ReCap™ reality capture software and the new features in 2014 Autodesk products specifically tailored for laser scanning.

Learning Objectives

At the end of this class, you will be able to:

- Define LIDAR
- Assess which is the right tool to use when laser scanning
- Set up for a laser scanning job

About the Speaker

Mr. Ikerd is a Principal at IKERD Consulting, a firm that provides engineering and Virtual Design & Construction (VDC) consulting services to architects, general contractors, sub-contractors and owners with a focus on integrated projects with Building Information Modeling (BIM). He brings over 15 years of 3D parametric information modeling and structural engineering experience to the firm's team. He has developed a firm that provides IPD and BIM consulting services to owners, construction managers, and subcontractors and building material companies in the construction phases of projects. He has also designed BIM specifications to aid in fully coordinating the construction models of all trades. Utilizing existing as-built 2D documents, CAD files or design models, depending on what information is available, the firm has aided projects in the creation of BIM content. The content includes civil, structural, MEP, medical gas, fire protection, architectural and façade systems. Mr. Ikerd has also facilitated on-site BIM coordination meetings for designers, contractors and owners.

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Define LIDAR

LIDAR (Light Detection and Ranging) uses lasers to measure the distance from a scanner to objects or surfaces. This information is compiled into 3D images of the areas or objects that were scanned, and can be used for precise measurements and planning.

Assess Which Is the Right Tool to Use When Laser Scanning

FARO Focus 3D

A number of viable options are available when it comes to laser scanning hardware and this presentation does not endorse or promote one technology provider over another. We do note that this presentation will give samples of using the FARO Focus 3D laser scanner. This scanner operates by producing dense point clouds with millions of points, all in a matter of seconds. These points form 3D color images and can be used for a wide range of projects, from measuring large building interiors to modeling cars.

Because of its scanning speed and portability, the FARO Focus 3D is a good choice in our opinion for large interior projects, as it can be moved from room to room. Additionally, it can be used for building exterior scanning around the perimeter of low rise buildings. It is also useful in small areas, such as narrow hallways, because of its compact size. And because it provides its own light source, it can be used at any time of day or night, without requiring electricity in the building for monochromatic scanning. Note that light is required if color scanning is desired, as the camera on the scanner will need the light to render color.

Application of Laser Scanning with ReCap

Before going out to the field to begin a scanning job, planning is key. The scanning itself is only one step in the process, and for a successful result, you must set up carefully, stay organized, and follow the guidelines you establish.

BIM Execution Plan

A BIM Execution Plan (BIM-EX) is very important to the process. This plan documents what will occur during the project, defines the Level of Development (LOD) of the project and gives the ability to reference important documents, such as the AGC BIMForum LOD 2013 Specification. Additionally, it gives guidance for other fundamental aspects of the modeling on the project such

as naming convention and definition of origin of the project. It also aids in defining scopes and roles of team members on the project and fundamentally gives a communication plan for how the data is to be collected.

This includes details such as how field notes are taken, maintained, and transmitted. Field notes are a central aspect of any site visit. These can be taken in a number of formatsas will be discuss in the field notes section of this docuemnt.

Origin

An important aspect of working with 3D models is the origin. When starting a job, it is vital to establish a system of coordinates early. Begin by opening a CAD file and saving it back to a previous version, such as 2010, so that it will be widely compatible for use by others. The coordinate system should be logical, in the southwest corner, so that all coordinates are positive. The goal is simplicity: not to make it easy to get right, but hard to get wrong. Typically, follow the design team's elevation, relative to finish floor (normally 100 Feet).

ReCap Set-Up

Begin by downloading ReCap 2014. It is approximately650 mB, so allow plenty of time for the download. When working with 3D modeling, or any files in general, it is important to have a logical file name that is consistently applied across the project. It should identify:

1. Who is doing the work
2. Where the work is in the building
3. Percentage complete (if applicable)
4. Date

If an architectural drawing of the building shows zones, such as A, B, C, etc., this can be used as a logical point of reference in file naming. To create spaces in the file name, use underscores instead of spaces. Many naming conventions utilize camel case as has been used in computer programming; capitalize the first letter of each word in the file name and leave the remaining characters lower case.

The goal is for all of the file names to line up in a column and be easily searchable. Using underscores and full words in the name allows a person to search for a specific file much more easily.

File "Renamer" Application

The final aspect of file naming is a powerful tool called File Renamer. This utility allows a user to rename whole collections of files at once. Using this program, you can select entire directories and subdirectories of files to be renamed in one step. The software was designed for simplicity, but is powerful enough for complex tasks.

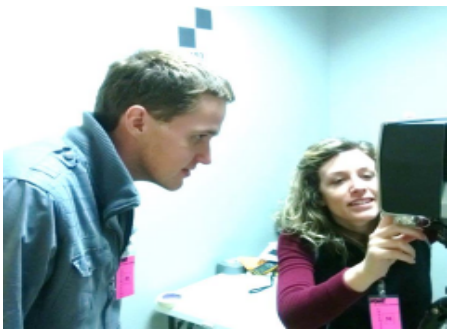
Field Notes

When scanning, it is critical to document information as you go to assist in the post-scanning work, which is a large percentage of the effort. If using traditional paper notes, it is wise to purchase high-speed scanners and digitizing the notes as soon as possible. This aids in sending the notes to team members and long-term documentation. Typically, the plan can be laid out from the architectural drawings that will show where the scans are being taken.

Our team typically uses BlueBeam Revu PDF editor for field notes when we have Windows based tablets and laptops. BlueBeam is compatible with the iPad as well. For Android applications, we have used FoxIt PDF editor. Our team has had good experiences with the Samsung Note 2 or Note 3 phone using the FoxIt PDF editor. The screen is large enough on these phone\tablet hybrids to see the PDFs and even mark up with the stylus.

Recording several items can be instrumental in staying organized, and can save countless hours later:

- Date and time of day
- Scan number
- Scan file names
- SD card and size (if you discover that one of the cards is bad, it is important to know which scans are on it)
- Scan density
- Whether it is a color scan
- Cardinal scan (a scan that ties to a survey point)
- Scan duration
- Any errors that occur
- Locations of key targets
- Names of technicians
- Scan path
- Names of onsite personnel whom you meet



Budgeting

No two jobs are alike. When working with laser scanning, consider three main areas: field collection, registration, and processing into a BIM federation tool such as Navisworks. If needed for more than just visual comparison, the scan data can also be prepared to go into a BIM modeling tool, such as Revit, AutoCAD 3D, or Civil 3D.

Lessons Learned from Laser Scanning

Each team will have to understand how efficient their group is. This is highly dependent on the tools they use, the team they take, and the hardware and software that they use. Efficiency is a function of the people, the place, and the things (scanner, computer, software). In addition, several other factors can contribute to a group's efficiency. Before beginning a project, we have discovered that it is important to determine several items:

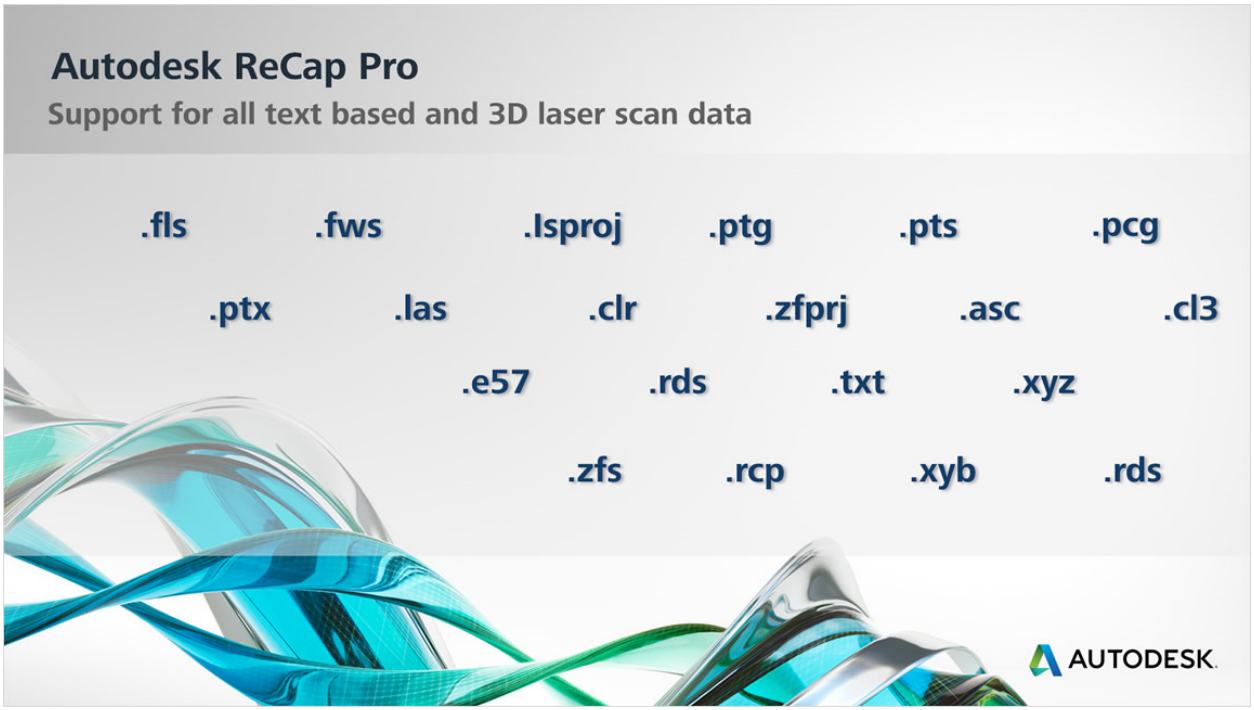
1. If you need to set up targets, find whether you can tape up paper targets, and whether you can leave them up.
2. If you are using spheres, find whether there are metal surfaces for attaching.
3. Weather conditions: humidity, heat, and cold can affect target application.
4. Location
5. Working hours
6. Whether the team will have to pause between scans (lengthening the process).

Benefits of ReCap

Autodesk ReCap has two versions, ReCap Pro and ReCap Photo.

ReCap Pro, which comes with the Autodesk Building Suite, offers a variety of features, including:

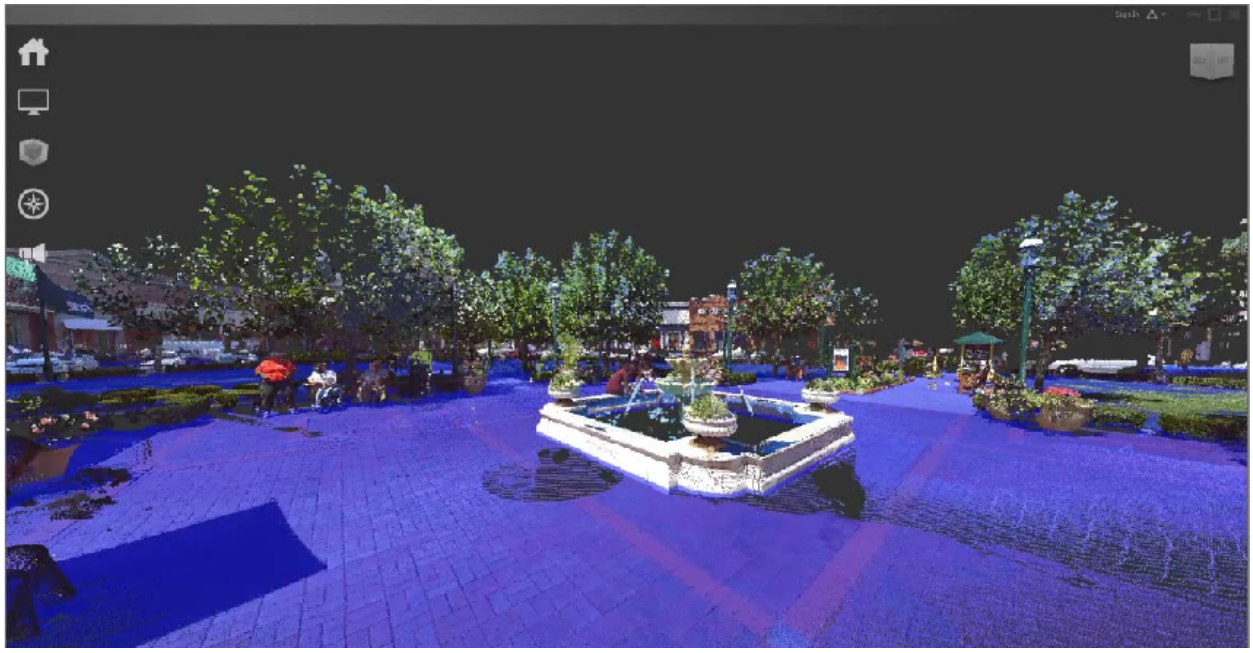
- Compatibility with multiple applications.



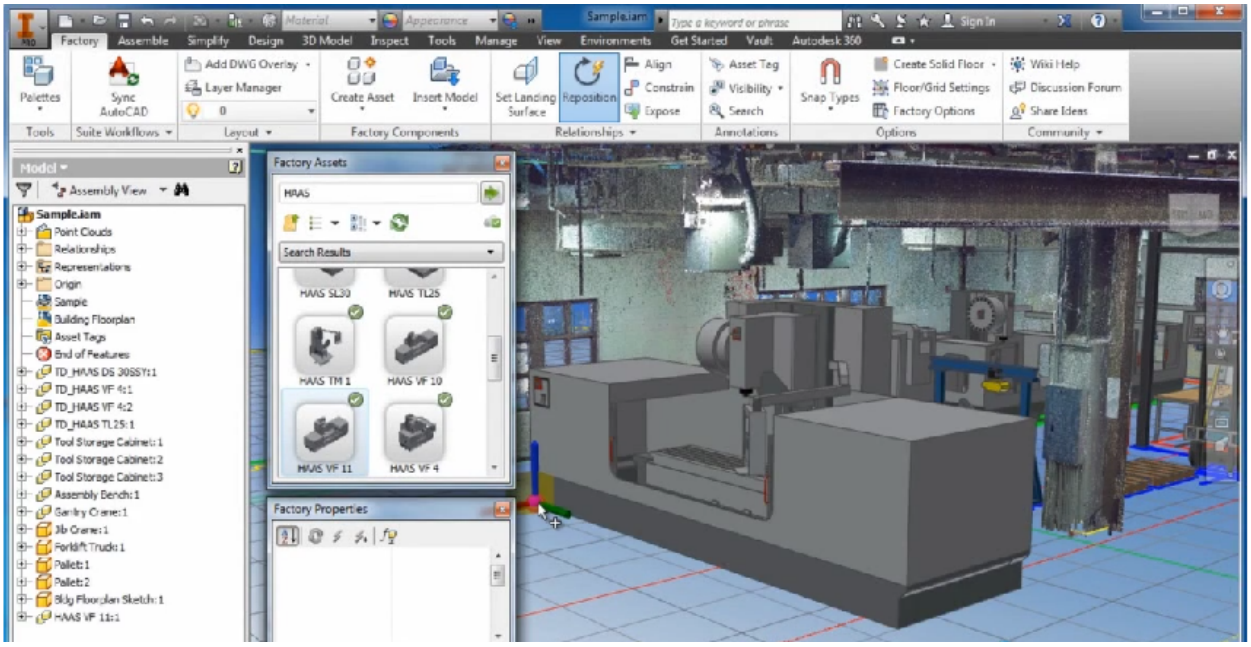
- 3D or Panoramic Photorealistic Visualization of Data

- Creation of As-Built Models, Using Laser Scan Data Alignment

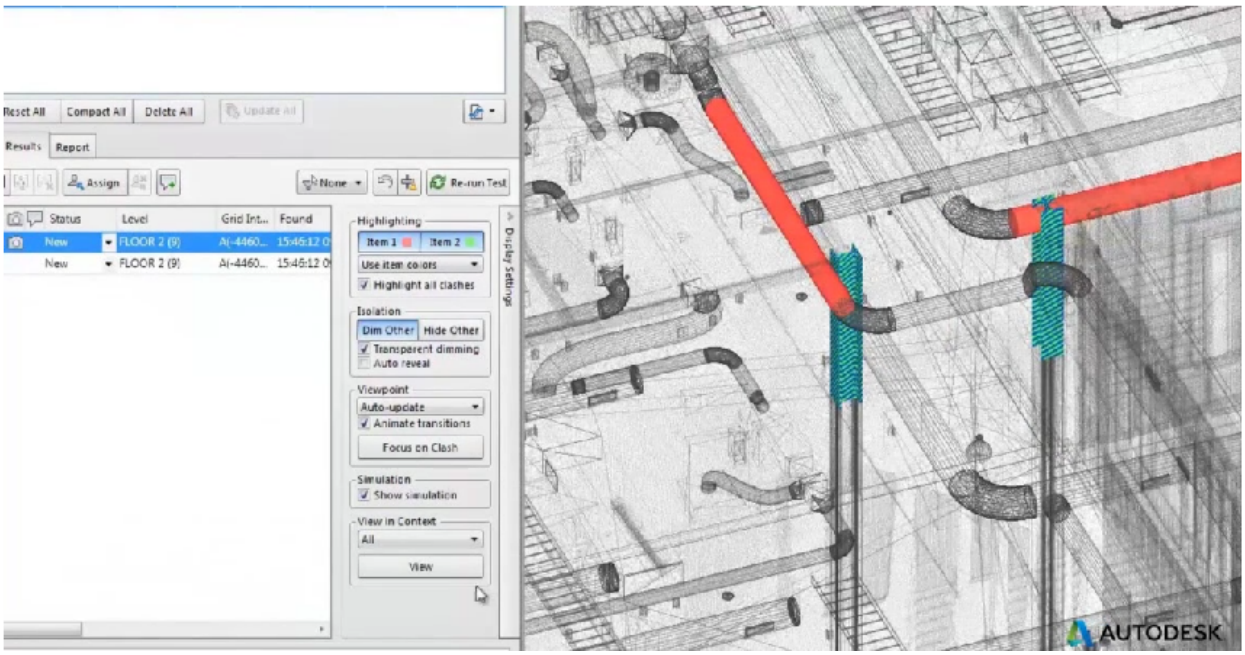
- Editing and Cleaning of Point Clouds



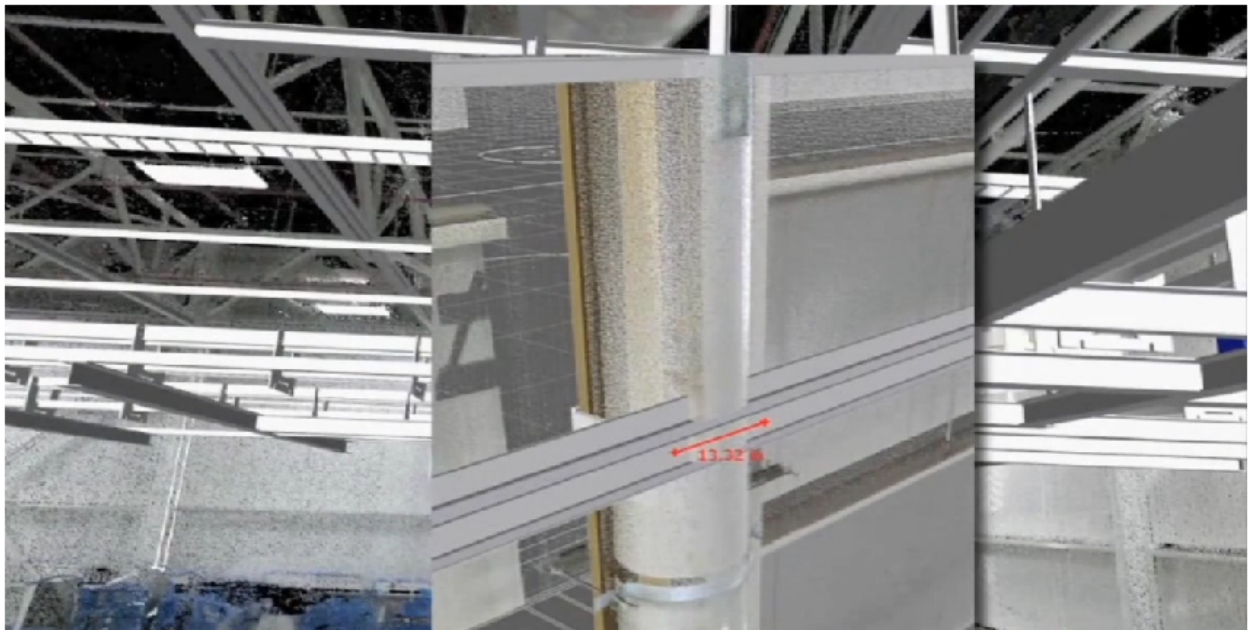
- Visualization of As-Built Conditions



- Verification of As-Built Conditions



- Clash Detection through Point Clouds



Recap w/ Revit 2014

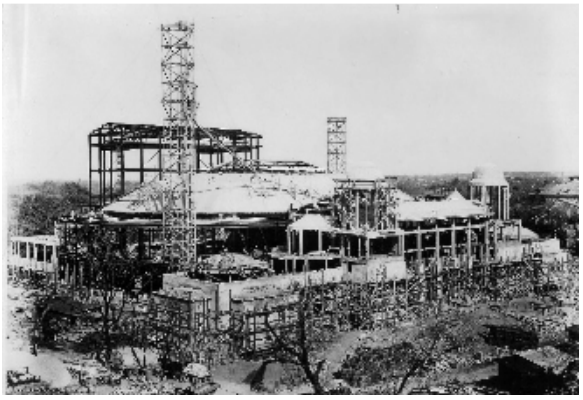
System Requirements for Autodesk ReCap Pro Recommended system specifications

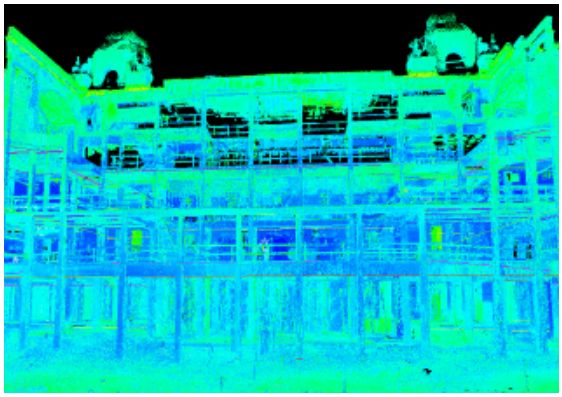
- Operating System: Microsoft® Windows 7 Enterprise (64-bit); Microsoft® Windows 7 Ultimate (64-bit); Microsoft®Windows 7 Professional (64-bit); Microsoft® Windows 8 (64-bit)
- 2.0 gigahertz (GHz) or faster 64-bit (x64) processor
- 8 GB or more RAM
- 1600x1050 or higher True color
- OpenGL 3.3 capable workstation class graphics card with 1 GB memory
- 20 GB + free disk space for processing
- Microsoft® Internet Explorer® 7.0 or later web browser

Minimum system specifications 64-bit

- Operating System: Microsoft® Windows 7 Enterprise; Microsoft® Windows 7 Ultimate; Microsoft® Windows 7 Professional, Microsoft® Windows 8
- 2.0 GHz or faster
- 4 GB or more RAM
- 1280x1024 with True Color
- OpenGL 3.3 capable graphics device with 256 MB memory
- 10 GB + free disk space for processing
- Install from download or DVD
- Microsoft® Internet Explorer® 7.0 or later web browser

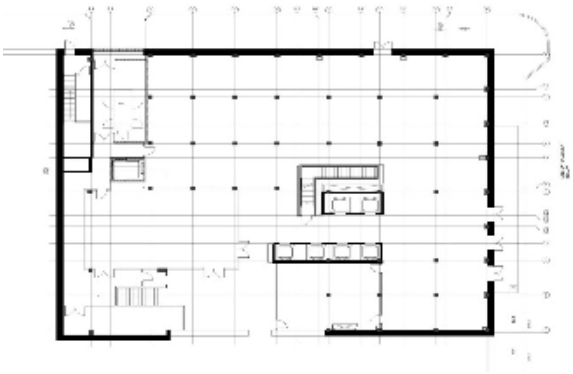
Case Study 1: 1926 Theater in San Antonio Texas

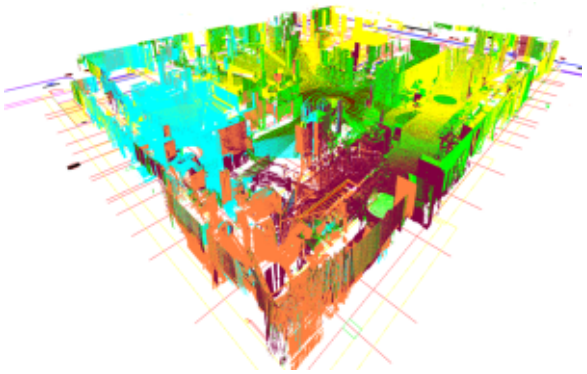




The Tobin Center for the Performing Arts is a historic concrete structure from 1926. Currently, it is undergoing renovations to become a world-class facility. This multi-million dollar project presented multiple scanning challenges; for example, it does not have a common orthogonal grid system. Also, because of the era in which it was built, it has notable construction tolerance challenges.

Case Study 2: 100+ year old office building in Houston, Texas





This concrete and steel frame building in Houston, TX is over 100 years old. The challenges for scanning were numerous, including:

- Sloping floor structures, which require sufficient density to measure slopes
- Construction tolerances, such as rivets in the steel, which need to be captured with higher density laser scans
- Lack of standard steel shapes (steel members that were build up from angles, plates, and rivets), which need higher density scanning to capture the geometry
- A small area for Tenant Interior (TI) Finish-out that needed a rapid turn-around on the schedule to document the existing structure

Additionally, the client needed the files in Revit. On projects like this, using ReCap with Revit can greatly simplify the process.

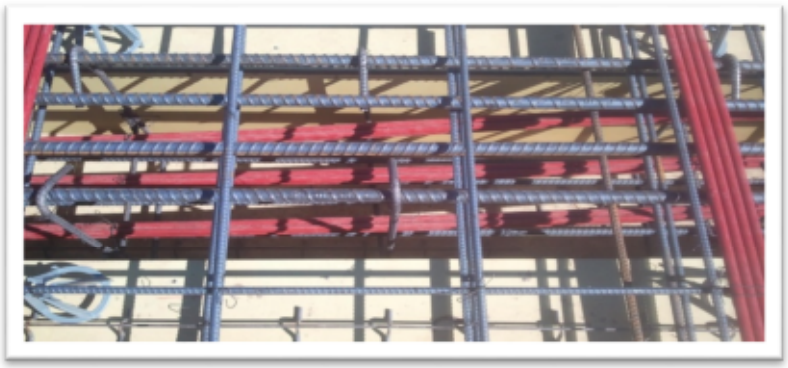
Case Study 3: 100+ year old Building Skin in Dallas, Texas

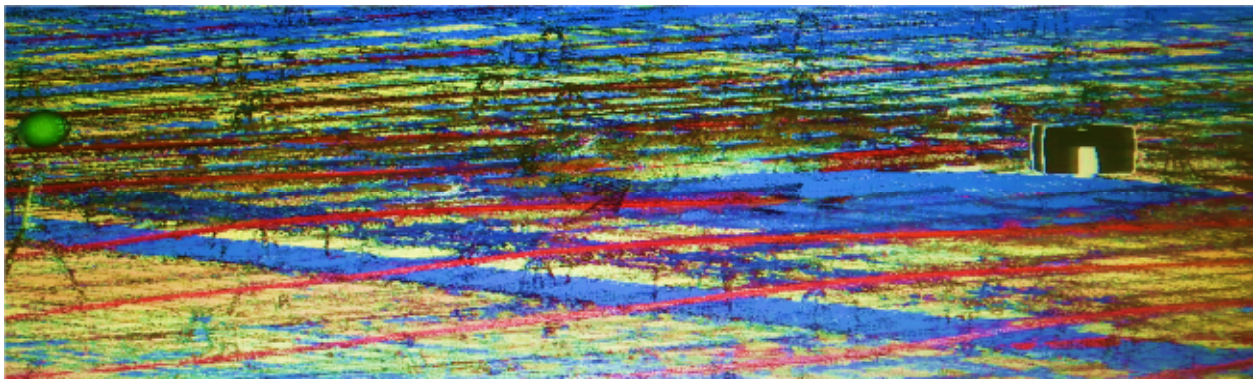
This century-old building in Dallas presented a number of unique challenges to the scanning team. For instance, the client wanted a color scan of the exterior of the building. This creates extra areas to plan – the time of day, for example, becomes a significant factor. We scanned near the end of the day and low light conditions affected the color of the scans. Also, you should understand the limitations of your scanner: our particular scanner functions well for lower stories, but can have challenges on upper levels. It was also important to the client to get high-density at lower areas for renovating the building envelope, so it is necessary to check the density required to meet the client's needs.

An important part of preparing for scanning is getting permission from adjacent property owners. Scanners are quick to set up and easily portable, but if you are using someone else's land, check ahead. You may need to pay for a parking space if scanning from an adjacent parking lot. It's best to establish good relationships in case you need to return later for additional scans.

Again, this is a case in which using ReCap is beneficial, because it handles using compression and color well, and can be taken into Revit.

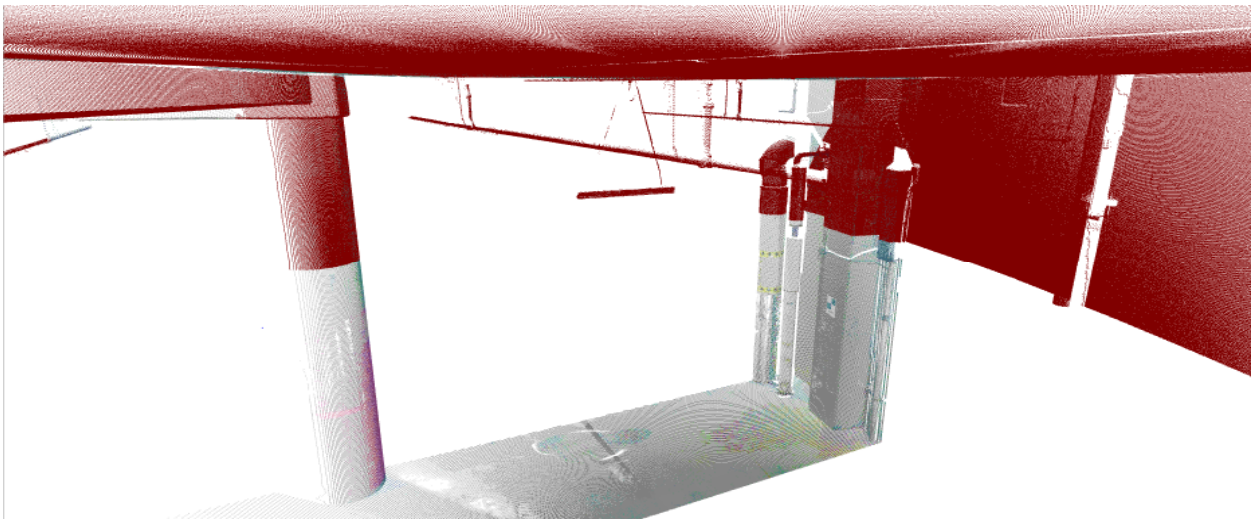
Case Study 4: Post Tension Cable Scanning





This PT tendon scanning project had several unique challenges. PT tendons come in three main colors: red, blue, or green (and occasionally yellow). Thus, scanning needs to be in color to take full advantage of the data. Another challenge is timing: this type of work has a critical schedule because scanning typically takes place the day before concrete is poured. So concrete workers may be on site, tying in rebar, and scanning must be worked around them. Also, the workers are moving, and this is form work, so vibrations on deck can be a challenge. We typically allow for a much larger tolerance of error due to these limitations. Additionally, we recommend using spheres for targeting because there are not many good natural targets to reference, and we place them so that they are attached to the column with rebar coming up. This rebar is much less likely to move because it is detached from the rest of the slab formwork. Targets should always be attached to stable surfaces. In your field notes, record items such as electrical J boxes (junction boxes for the electrical). These can be seen under the slab on the floor below when the formwork is removed, and can be useful in referencing your scans. The benefits of ReCap in this type of work are its ability to handle the color scans and compress them, and then bring them into Revit.

Case Study 5: Existing Structure, New MEP in Ceiling



This project involved scanning an existing concrete building with new mechanical. It was a detention center in Dallas with approximately 300,000 square feet of laser scanning for mechanical upgrades on three floors of a county jail. The challenges included working in detention center conditions – when working in a secure area, you must consider what you can take onto the work site. Tools will have to be approved, like box cutters or hammers. Also, good field notes are essential, because you don't want to need a second trip to jail! On this project, we were scanning a mezzanine floor with very high structure and we needed high density on the upper half only. The client wanted the files in Navisworks, and for the workflow we worked with what we call a high-density cap: low-density scans can be exported for the overall room and high-density files for the upper six feet of the ceiling. This minimized the file sizes in Navisworks. It gave high enough density to see pipes and smaller diameter mechanical/electrical content, but did not bog down the models with a lot of scan data, which the client found helpful. With ReCap you can zone and segment levels and export them out separately, and adjust the densities of exports.

Case Study 4: 50+ Year-Old Working Hospital

This was a large hospital with numerous buildings and approximately 1,000,000 square feet of scanning. It was composed of predominantly concrete buildings with some structural steel mezzanines. This project, because of its sheer size as well as the nature of the particular job, held many challenges. We had up to five scanners working at one time, so naming conventions were extrememly important, as was documenting field notes. Each day the Project Manager checked and updated the pdf, or scanned the paper notes.

This project took full advantage of ReCap. It would have been much more difficult to complete a project of this size without ReCap and its ability to compress files. We elected to bring the ReCap files in one by one into Revit and did not export a whole group. Instead, we exported scan by scan. In Revit, we brought in one ReCap file per scan and then grouped them together in Revit. This allowed us to ungroup when needed, as well as isolating or hiding scans. It also maintained the scan number in the Revit files. The origins were important to keep documented throughout, because we finished with a little over 6,000 scans. We used powerful computer systems (64 GB of RAM and solid state hard drives). These hard drives notably improved the performance when working with the scan data. Our overall computer challenges included storing this magnitude of data and keeping track of it. We had over 20 days in field with four or five scanners going for long shifts.

Keeping multiple scanners and teams organized made the preplanning and BIM Execution Plan crucial. Working in a hospital also has security challenges (pharmacies with narcotics, operating rooms, and sterilization rooms, for instance). Extra time for working with these issues needs to be budgeted when planning a job in a sensitive area such as a hospital. They also had specific regulations. For example, paper targets had to be taken down within a week of putting up, so targeting had to be well coordinated with scanning. Before beginning a job, you should ask for any requirements like this, as well as finding out rules on the following:

- Putting up targets (some areas may not allow paper targets to be affixed to the walls)
- Work zones
- Dealing with emergencies (know protocol for when they arise)
- Infectious areas
- Dark areas (rooms that will have to remain unscanned)
- Master of keys (finding out who can let you into each room)
- Confirming with on-site police (they may be the only ones with keys for specific security areas)

There may be many other factors, but these should be considered. Also, it is important to keep in mind that you are hired by the client, not the staff. The doctors, nurses, patients, and patients' family likely do not want you there, or may not understand why you are there, so the sociology of the team is very important. Also, unusual work hours added stress. Because it was a

functioning hospital, we worked from 6pm to 6am each day. Once we finished the night's work, we were required to submit a daily update that morning. There were additional challenges from dealing with clients and the clients' clients.

ReCap made this nearly impossible task manageable. While still challenging, we were able to finish the scanning within our time frame and then organize the vast number of scans for our clients.

References

Images of Autodesk ReCap Pro on pages 6-9 are taken from Autodesk's site:

http://www.autodesk.com/products/recap/features/recap-pro/all/gallery-view

System requirements for ReCap Pro are also taken from the website:

http://usa.autodesk.com/adsk/servlet/ps/dl/item?siteID=123112&id=21693502&linkID=21623752