Laser Scanning During Construction: Five Case Studies Demonstrating Practical Use

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Skanska Innovative Construction Solutions

AUTODESK. UNIVERSITY

About the speaker

Danielle O’Connell

Senior Manager of Innovation Services with Skanska USA. Prior to joining Skanska she held roles in technology, as an owner and CM/GC. Over the past twelve years, Danielle has worked with organizations and project teams to aid in the adoption and implementation of new technologies, most notably BIM and VDC. She received a BFA in Architecture and Design from UMass Amherst.

About the speaker

Evan Reilly

Innovation and VDC Engineer with Skanska USA.

Prior to joining Skanska in 2017, he studied Civil & Architectural Engineering at Duke University.

Evan was born in New York City, grew up in London, England, and now resides in Durham, North Carolina. He is passionate about mastering new technologies that drive innovation in the construction industry.

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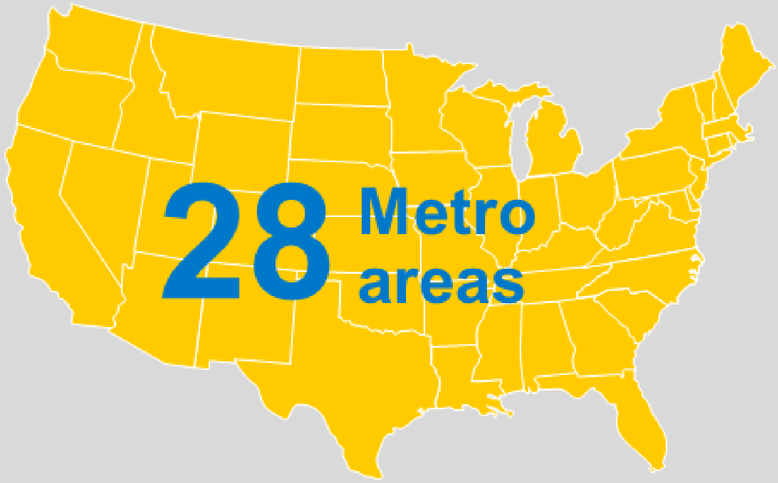
Skanska USA

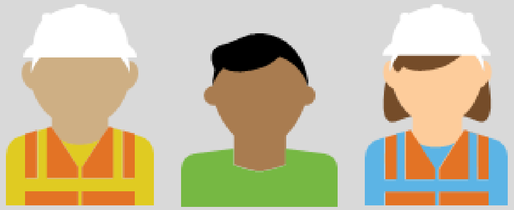
3 business units

Building

Civil

Commercial Development





9,000 employees

$3M annual community investment

$8.1B in 2018 revenue

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Notable Projects

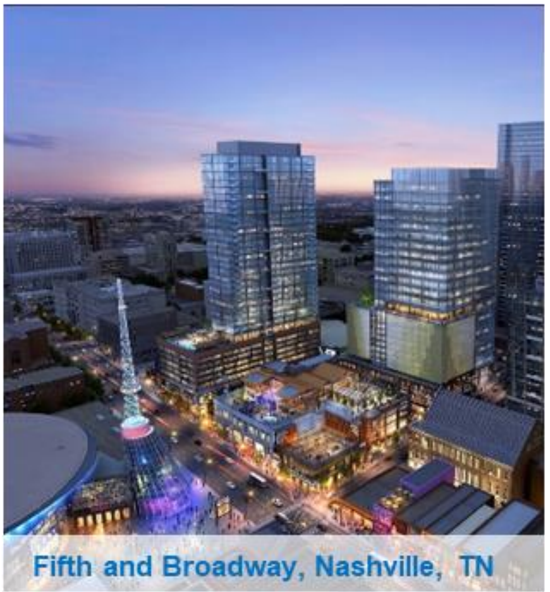
LaGuardia Airport Terminal B Redevelopment, New York, NY

Bank of America Tower, Houston, TX

Moynihan Train Hall, New York, NY

Florida Polytechnic University, Lakeland, FL

2+U, Seattle, WA



Fifth and Broadway, Nashville, TN

George Washington Bridge, New York, NY

The Westside Subway, Los Angeles, CA

Portland International Airport (PDX) Concourse E Extension, Portland, OR

Expo Line, Los Angeles, CA

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Laser Scanning During Construction: Five Case Studies Demonstrating Practical Use

Course Description

Laser scanning is nothing new. The tools have been around for years now, but the spread of incomplete knowledge about the technology has created a stigma that devalues its true capabilities. As with any “new” piece of technology, the value is limited by the implementation and workflow more than the tool itself. This class will provide five examples of uses demonstrated on projects this past year. The focus will be on practicality—where time and labor are often short on construction sites—and simplicity. Whether we want to determine the plumbness of a wall, or the flatness of a slab, or we want to back check as-builts of brick ledges, tie utilities into an existing building, or create a template of a repetitive room for quick modeling and coordination purposes, this class will explore what it takes and what we got from it—unfiltered.

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Learning Objectives

Objective 1

Learn how to apply laser scanning to assist in QC efforts in the field.

Objective 2

Learn how to determine use cases where laser scanning can improve workflows.

Objective 3

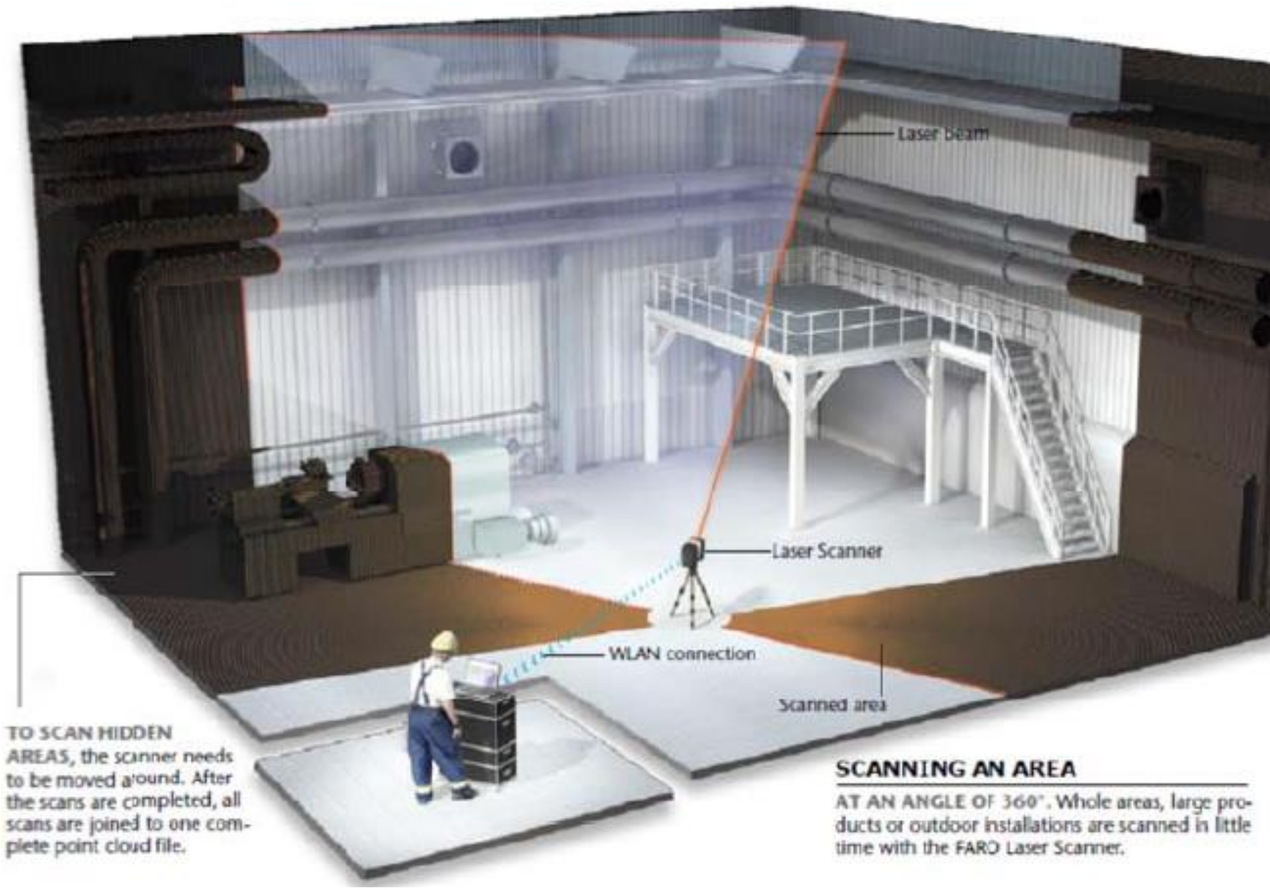
Learn how to identify opportunities to demonstrate innovative thinking on construction projects.

Objective 4

Learn how to build new workflows entirely to decrease rework and increase productivity.

Considerations

- **Line-of-sight technology:** if we cannot see it, we cannot scan it
- **Access of the space** = access of data



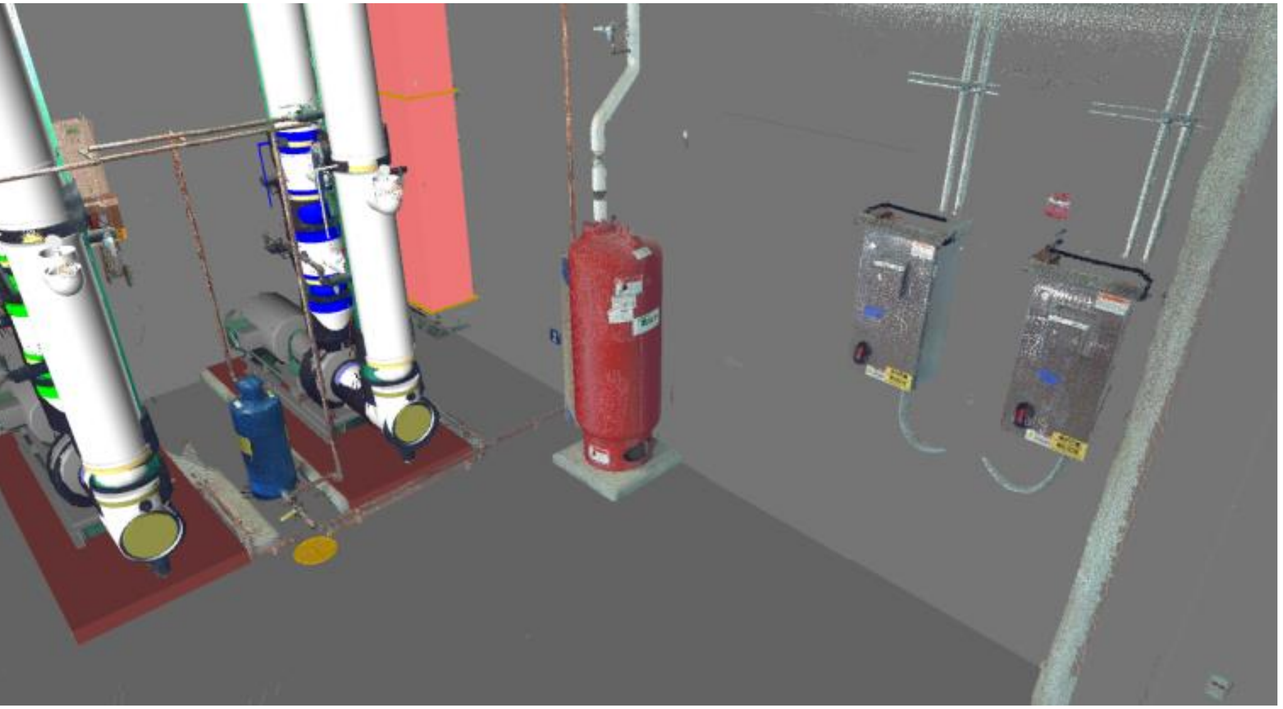
Laser Scanning Uses

Rapid Data Collection

- Millions of measurements in a short period of time
- High/hard to reach spaces, no ladder required

Existing Conditions Verification

- Provides accurate measurements of structure, MEP, etc., increasing predictability in the field



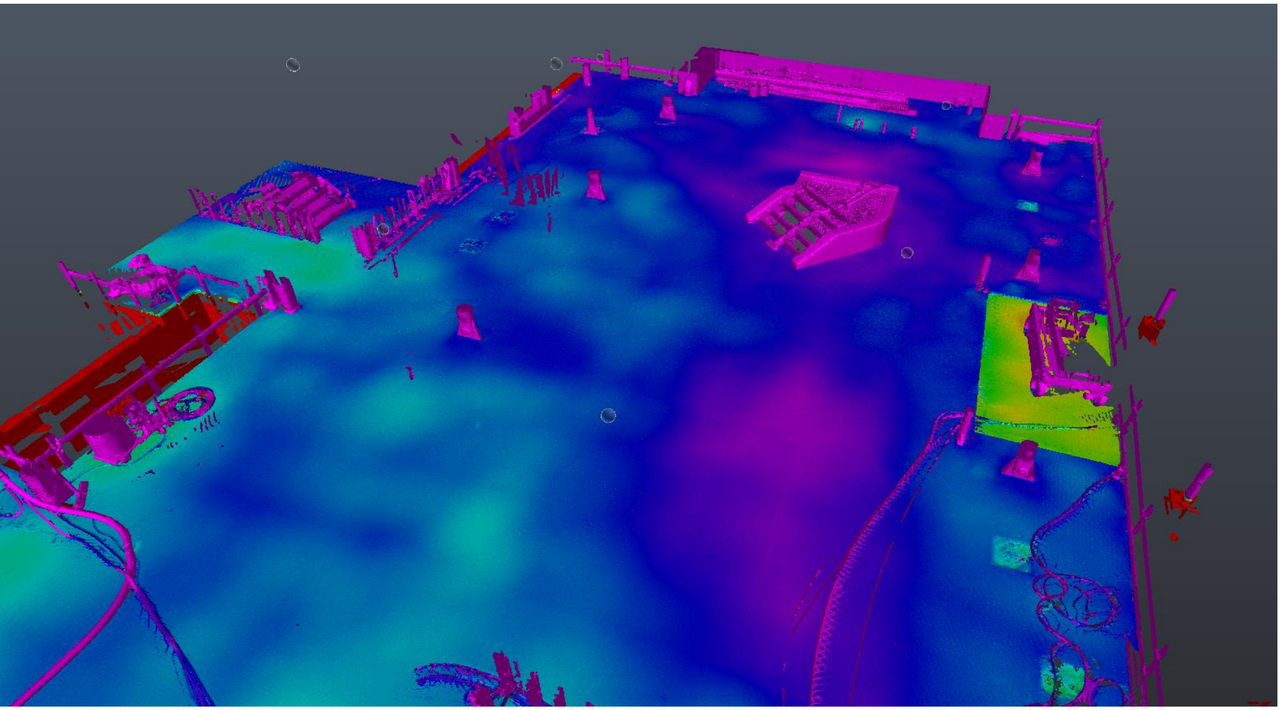
Documenting Construction

- Existing/current conditions capture
- Real time as-built conditions capture and progress review

Accurate As-built Conditions

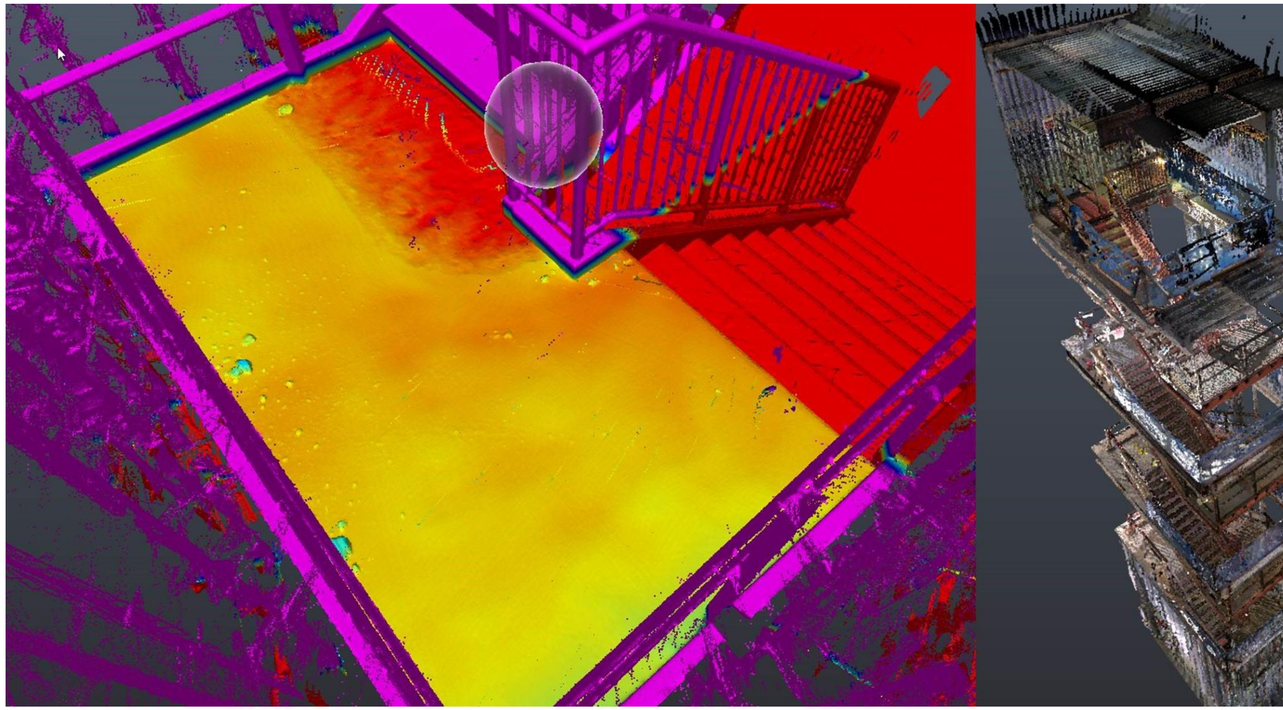
- Accurate verification of systems or for turnover and asset management
- Systems tolerances (i.e., steel and concrete) can be collected and verified.

Use Case 1
Levelness Detection



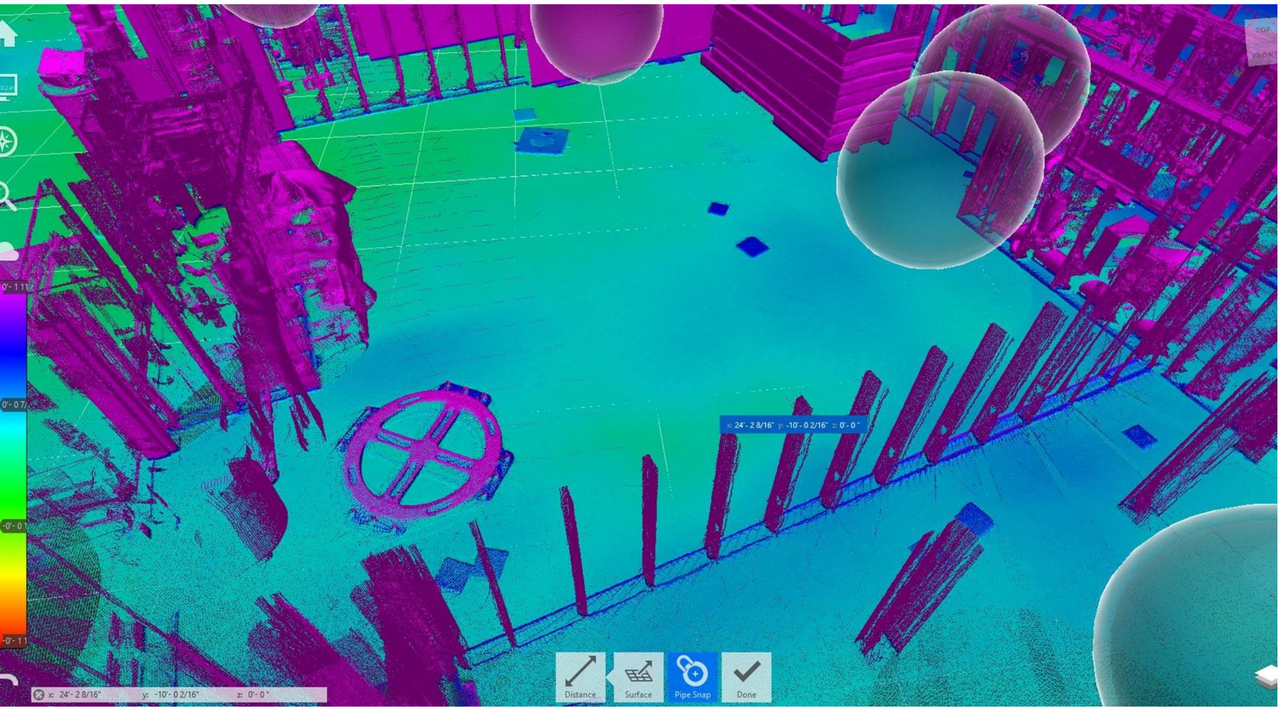
Levelness of Floors

- Verified concrete slab installed within tolerance prior to terrazzo installation.



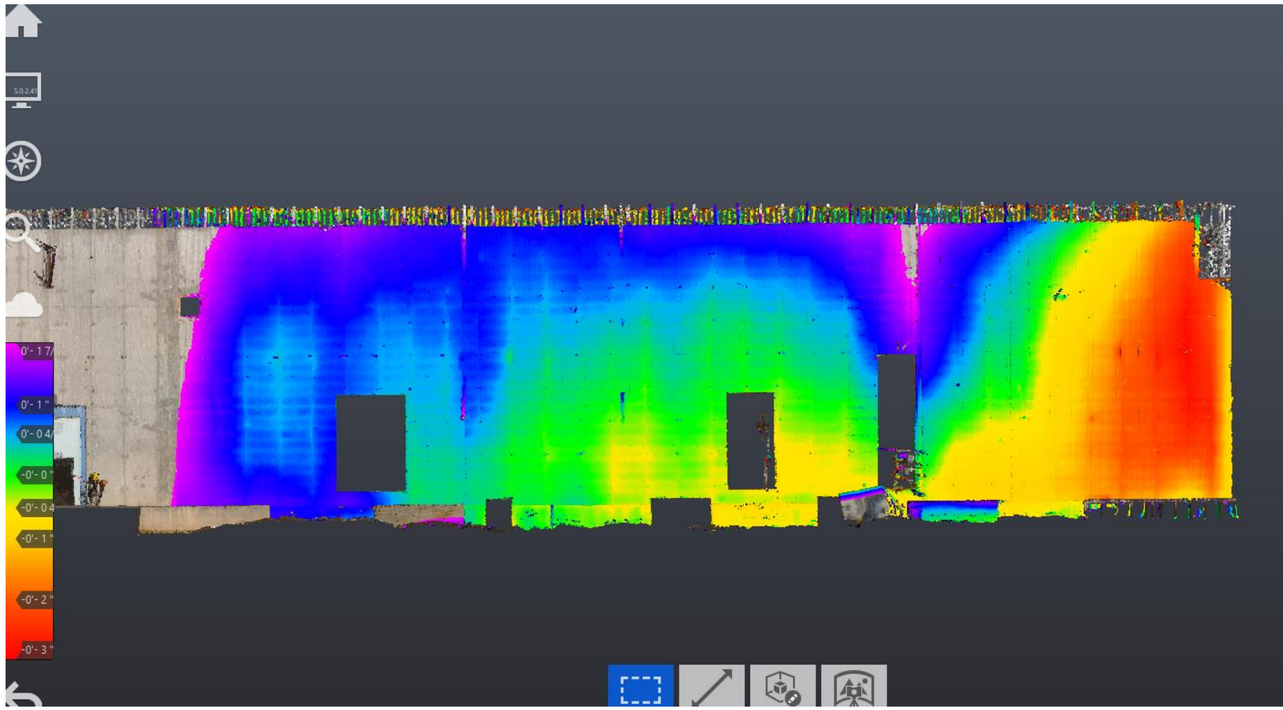
Levelness of Stair Landings

- Verified stair landings not installed within tolerance.



Levelness for Medical Equipment

- Verified floor installed within tolerance prior to medical equipment installation (±3/64”).



Wall Defects

- Scan confirmed areas with visual defects in concrete wall.
- After reviewing with team, determined that wall would not be demolished and made minor adjustments to brick exterior.

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Lessons Learned

Similarity of Applications

Horizontal flatness analysis for slabs can also be applied to finish floors, stair landings or even vertical surfaces like SOE or walls.

Logistics

Scanning in high-traffic areas (corridors, stairs) requires communication with field personnel and blocking off doors and access to areas during scanning operations.

Communication

For heat maps and elevation analysis, it is helpful to indicate the known zero reference point.

Deliverables

Be sure the project team has a clear understanding of what they are asking for and that they have the right software/tools to review the final data.

Use Case 2
Existing Conditions Survey

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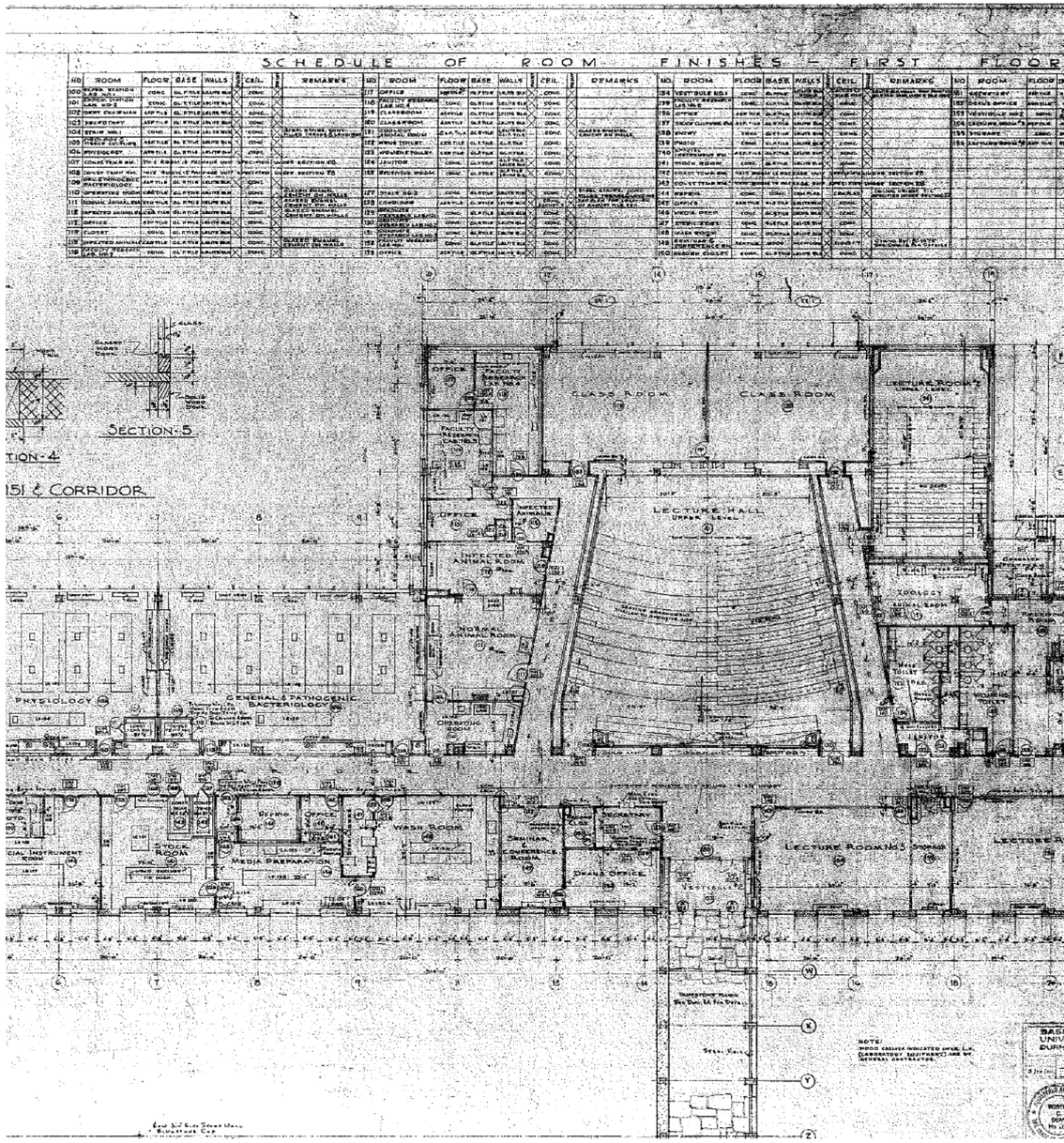
Existing Conditions Survey

- **Quality of Drawings**
  - Scanned in PDFs
  - Hard to read and decipher
  - Did not capture updates to the building spaces over the last 50+ years

- **State of Design Drawings**
  - Preliminary design drawings in 2D only and intended for conceptual planning and exploration of potential project phasing options
  - Conceptual drawings based on 1950s drawing set



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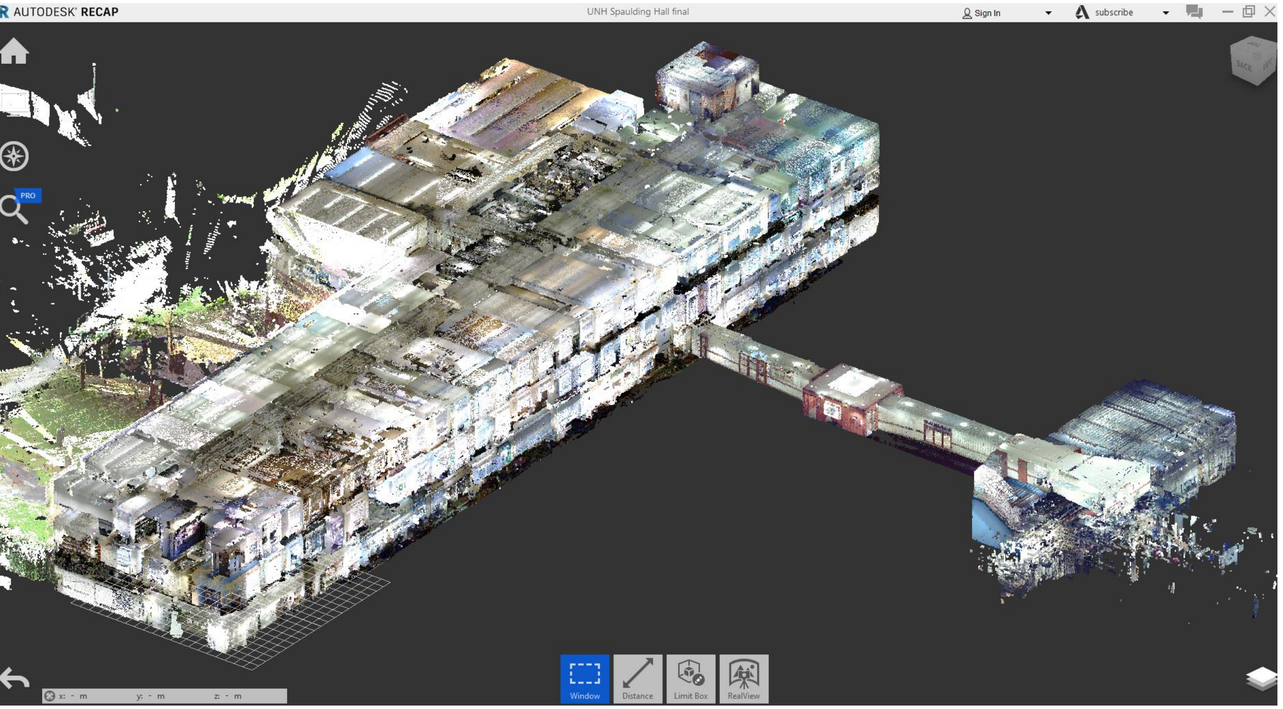

Overall Building Scan

- Captured every room, above and below ceiling, including mechanical and crawl spaces.

Building Floor Plans

- Design team used the point cloud to create level-by-level plans of the existing conditions.

Above Ceiling Conditions

- Scanner was placed above all drop ceilings to capture existing MEP/FP systems, which were then documented by the engineering team.

Building Sections

- Building sections were cut through a model and point cloud overlay to easily identify slopes of existing floors in various locations throughout the building.

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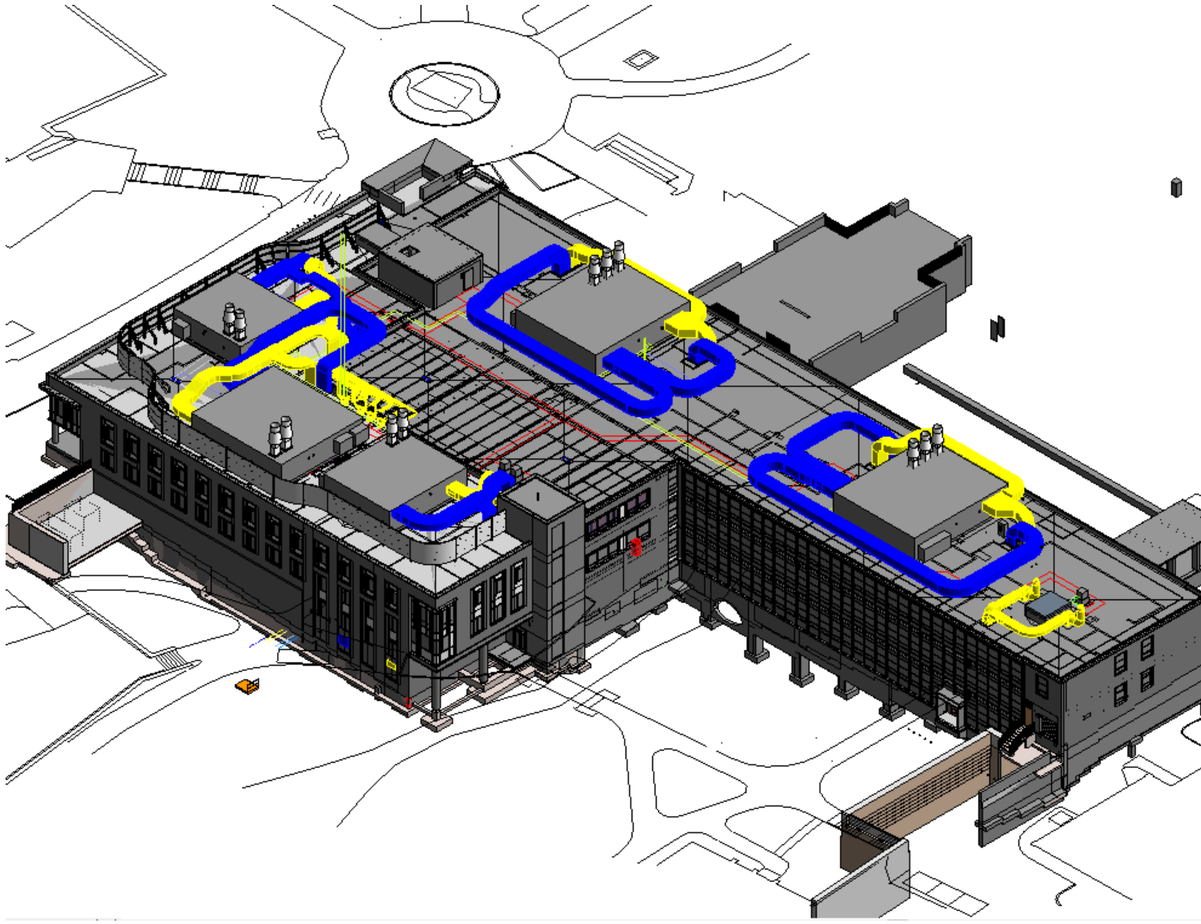
Revit Model Development

- **Project A/E used scan files to develop their existing conditions and renovation models**
  - Coordinate tie-ins to new building addition
  - Design of new systems
  - Coordination with existing MEP/FP systems
  - Understand limitations of existing conditions



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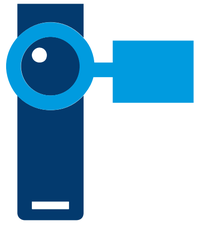
Lessons Learned

Safety

Drones were used to scan exterior spaces such as the roof in order to avoid possible asbestos and need for accessing the roof with the scanner.

Proper Planning

A site walkthrough would have been beneficial to better understand the existing conditions rather than relying on the provided as-built drawings.



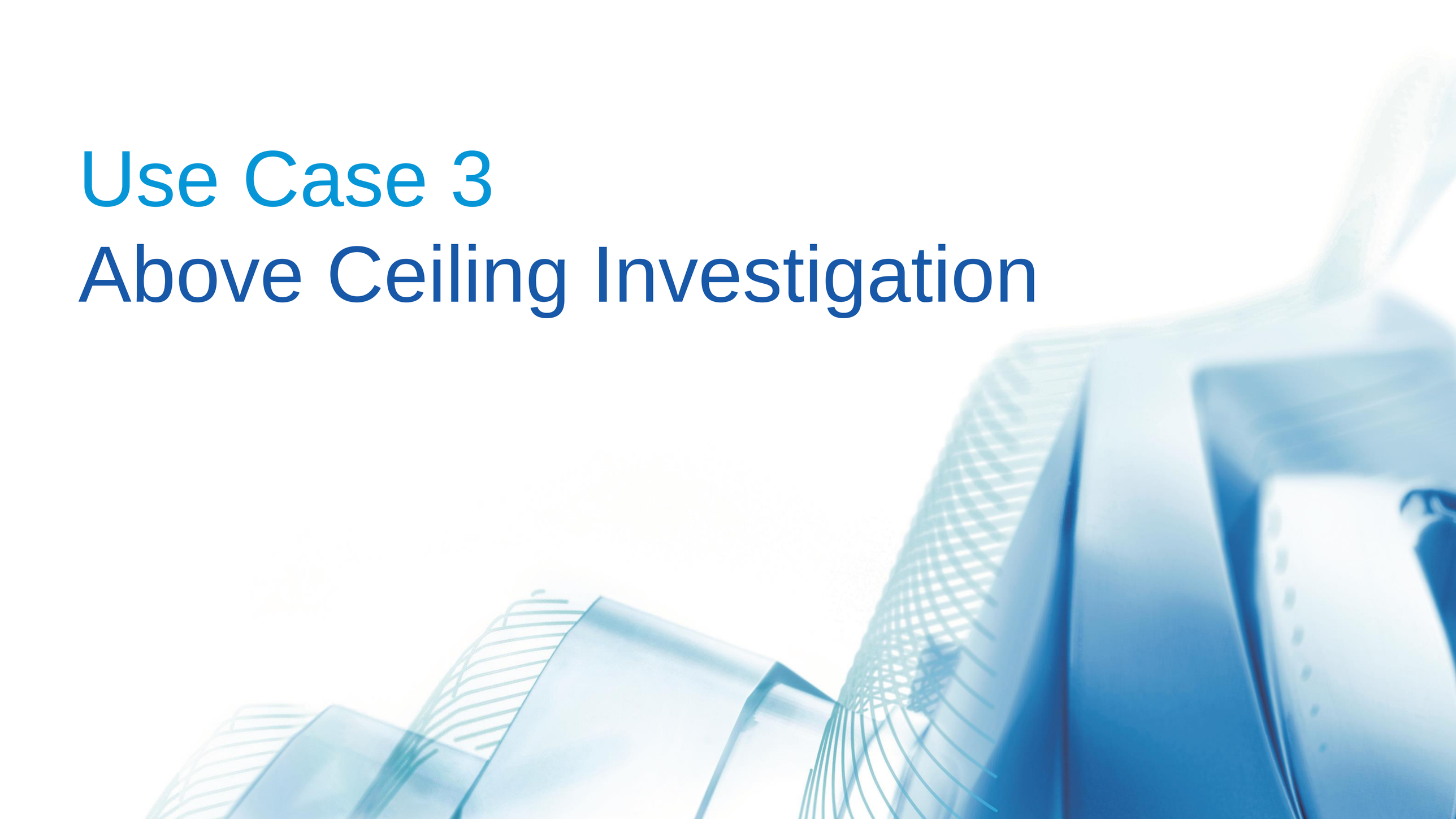
360 Photos

The use of 360 photos could have been used to enhance this process, especially in hard to reach spaces, crawl spaces, and above ceiling locations.

File Size

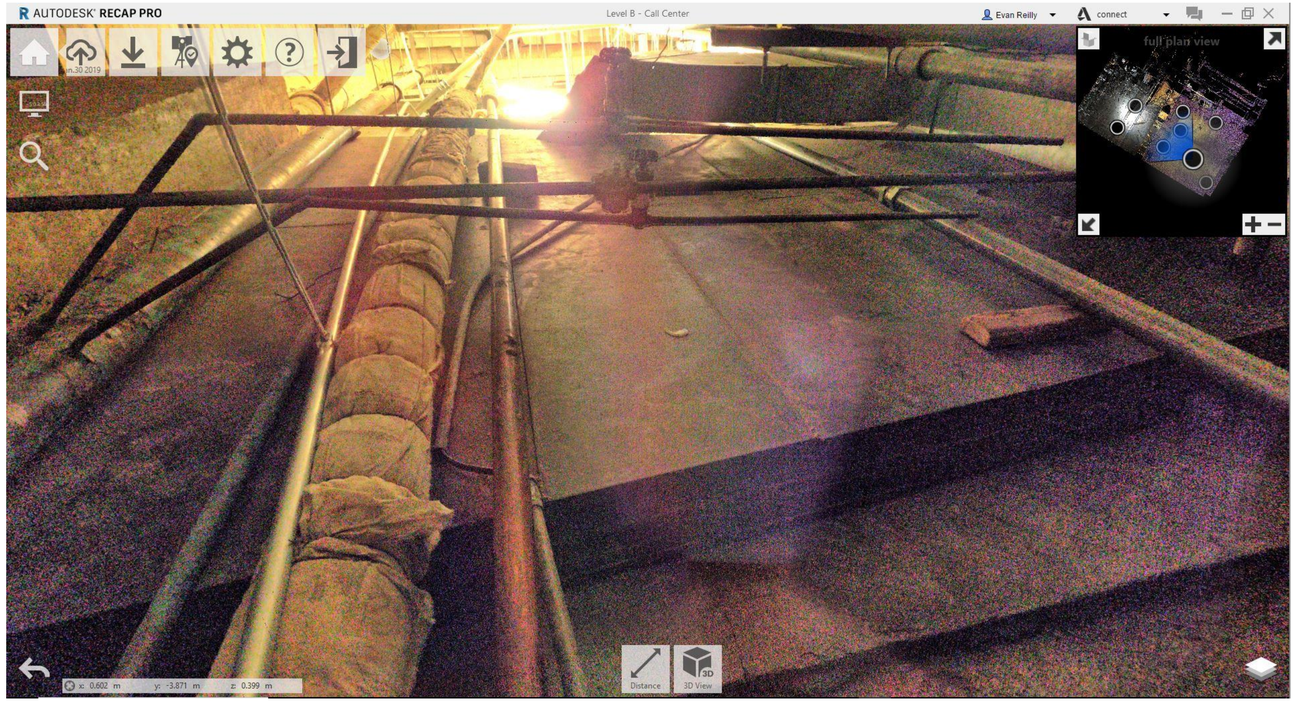
Plan ahead for how the design team would like to receive the point cloud files and how they can be broken up by area, floor, or in another way to best interact with the large files.

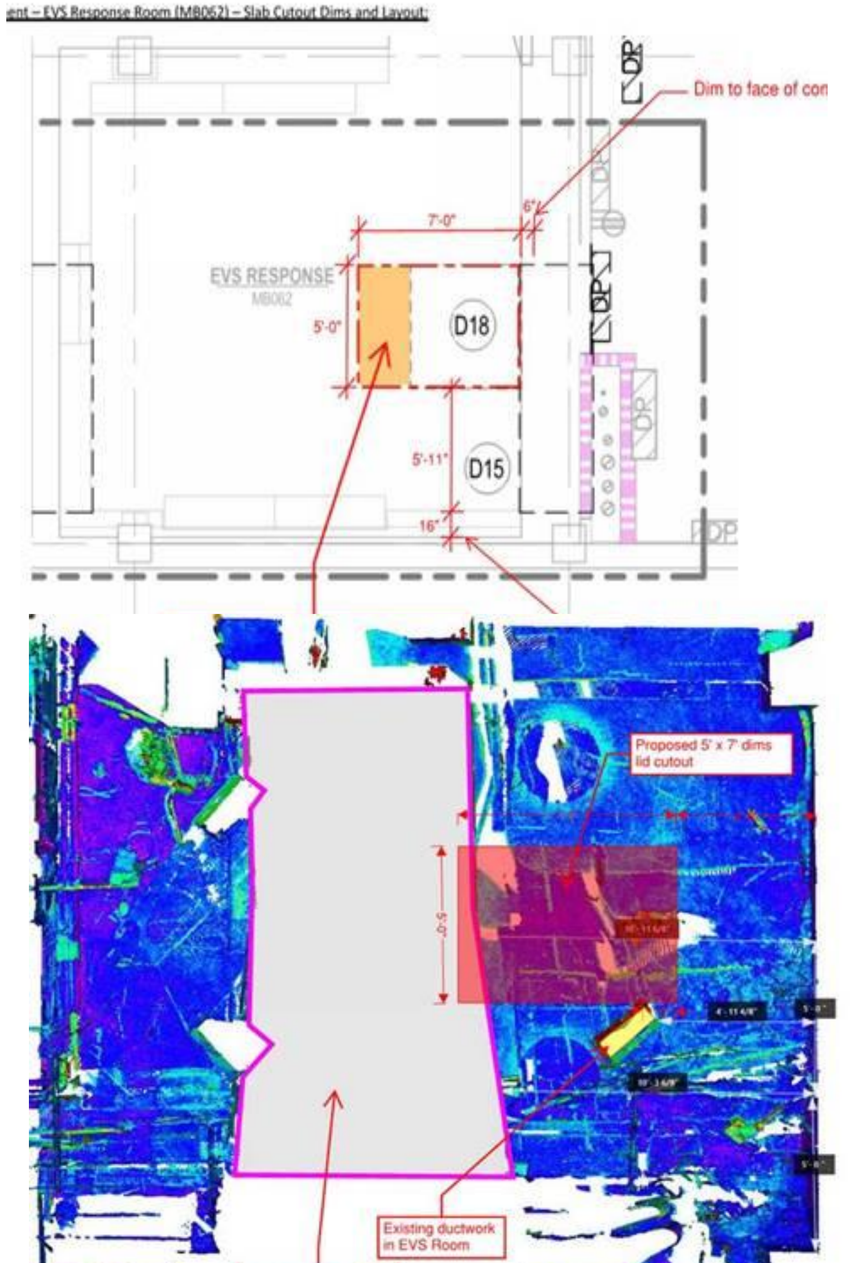
Use Case 3
Above Ceiling Investigation



Above Ceiling Investigation

- Utility tie-ins in existing building required working in cramped above-ceiling areas with limited access and unknown obstructions
- Identified steel plates over concrete vault ceiling where slab openings were to be cut for new utilities
- Shared results and 360 photos with structural engineer and demolition sub via ReCap 360 prior to mobilization





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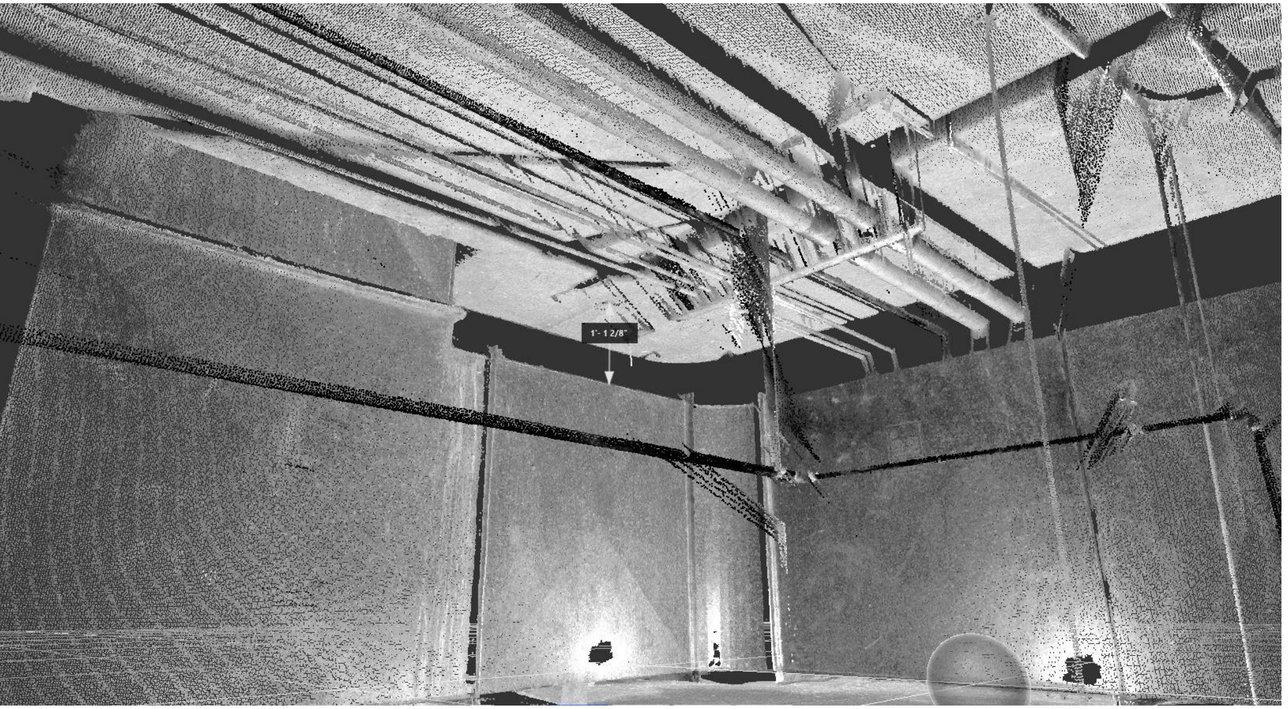

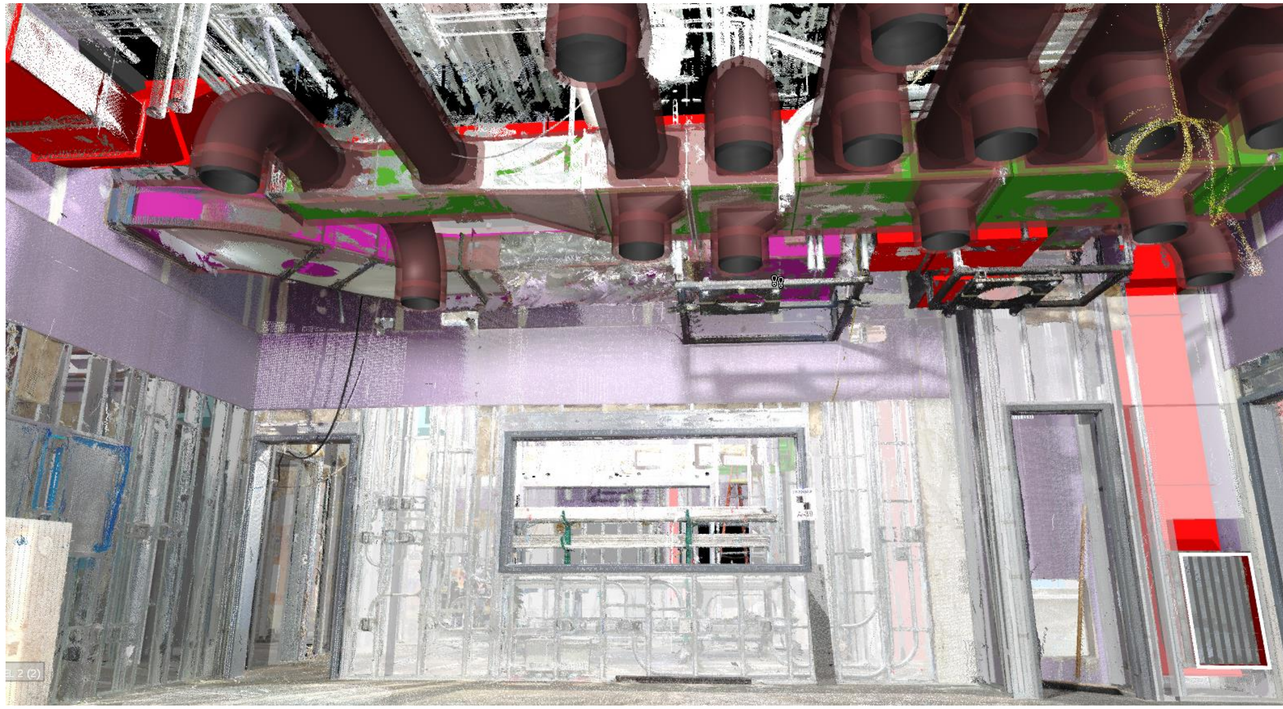

Above-Ceiling Investigation

- Collected laser scan data for coordination of proposed re-route of new electrical conduits
- Identified 13” void between top of existing duct and bottom of concrete slab to run 12 new 4” conduit, when design showed 5” gap

Scan vs. BIM for Overhead MEP

- Verified mechanical duct installed per coordinated model and identified missing equipment.

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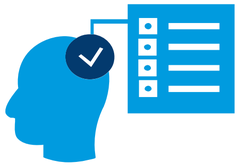
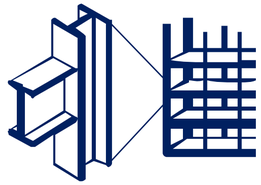
Lessons Learned



Planning

Having the right equipment for the job is essential for hard to reach spaces such as above ceiling where ladders, lighting, and telescoping tripods are required.



Improved Transparency

Allows for extremely accurate existing conditions documentation beyond what is shown in the drawings which aids in planning for phasing, demo, and install.

Model and Drawing Updates

More accurate representation of field conditions can be captured in drawings and models used for coordination and install.

Safety

Laser scanning in congested, inaccessible, hazardous or complicated areas can present an opportunity for multiple project team members to visualize these spaces in a safe environment during a meeting.

Use Case 4
Tenant Fit-Out

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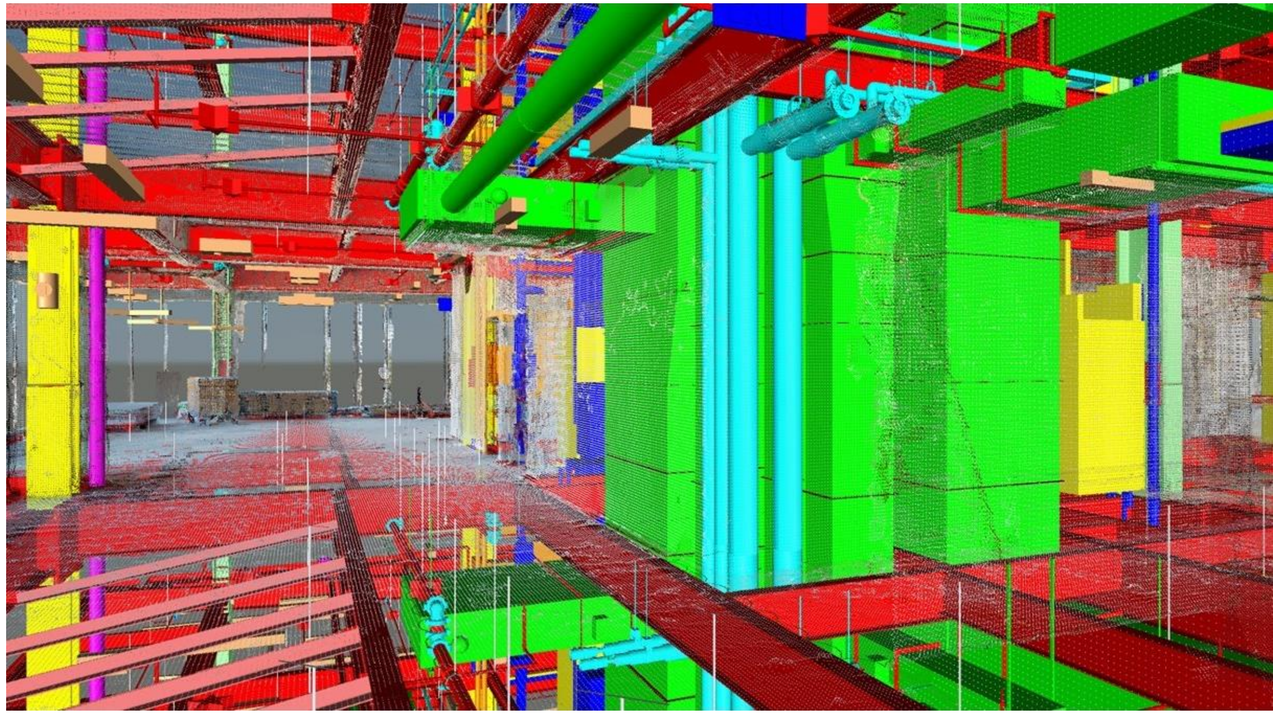
Tenant Fit-Out

Matterport was used as an alternative to LiDAR scanning to capture as-built conditions in preparation for tenant fit-out project.

- Used for confirmation of as-built conditions provided by core/shell contractor
  - .xyz export from Matterport used to overlay onto Navisworks models to identify variances.
  - 360 photo tour allowed for subcontractors to virtually walk through the space to better understand the existing conditions.

Immersive Environment

- The use of the Matterport cloud allows for immersive and photorealistic walkthroughs as well as the ability to snap dimensions as needed.



Core/Shell MEP/FP

- Allowed for verification of what was reflected in the as-built model vs. installed in the field for MEP coordination.

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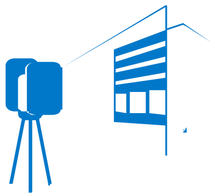
Lessons Learned



Accuracy

Scan accuracy ranged from 1-5 inches across a single floor.

More Scans

While scans were completed in 20 seconds, setups were required every 5-8 feet in order for them to align properly.

iPad Limitations

Our iPad app crashed mid-scan due to the number of scans captured and the storage limitations on the iPad.

April Tags

We learned after we completed the scans that targets called April tags could have been used to increase accuracy.

Use Case 5
Excavation and Shoring

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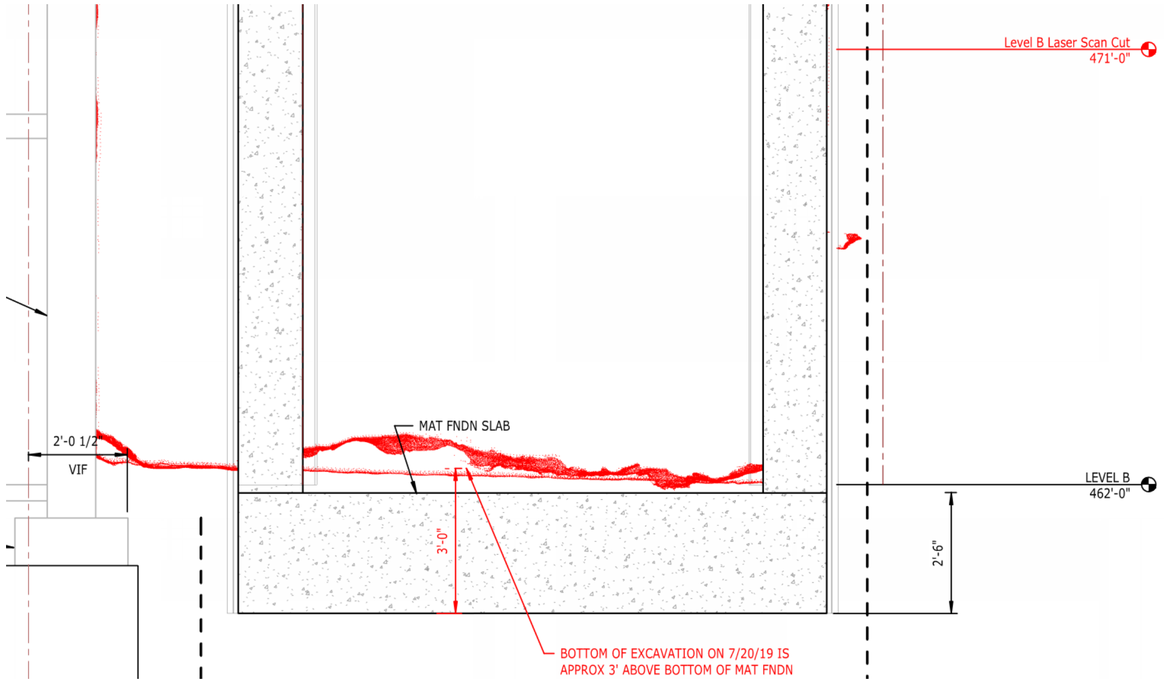
Excavation Depth Verification

- Discovered bottom of excavation was three feet above required design elevation
- Directed sitework subcontractor to finish incomplete excavation



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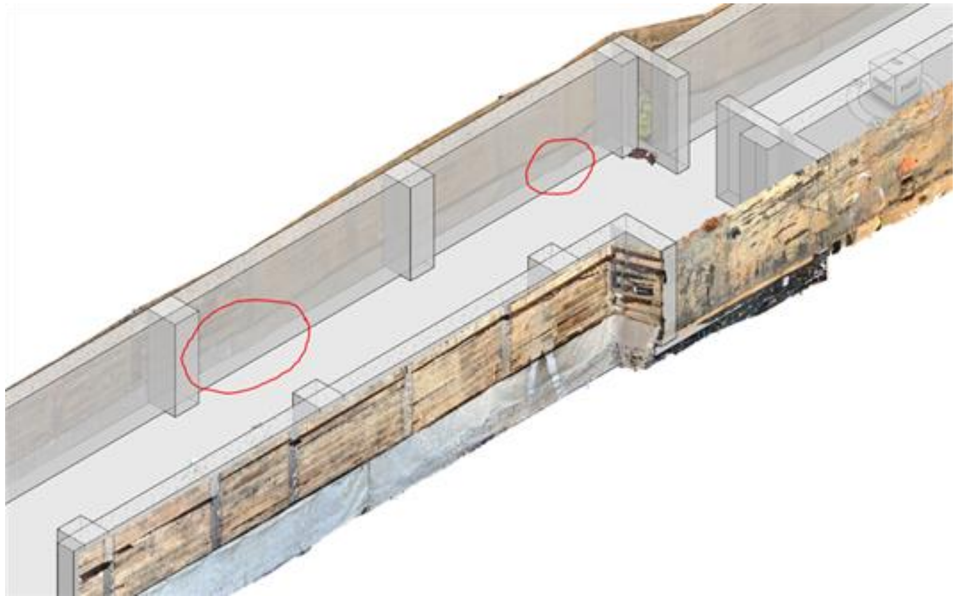
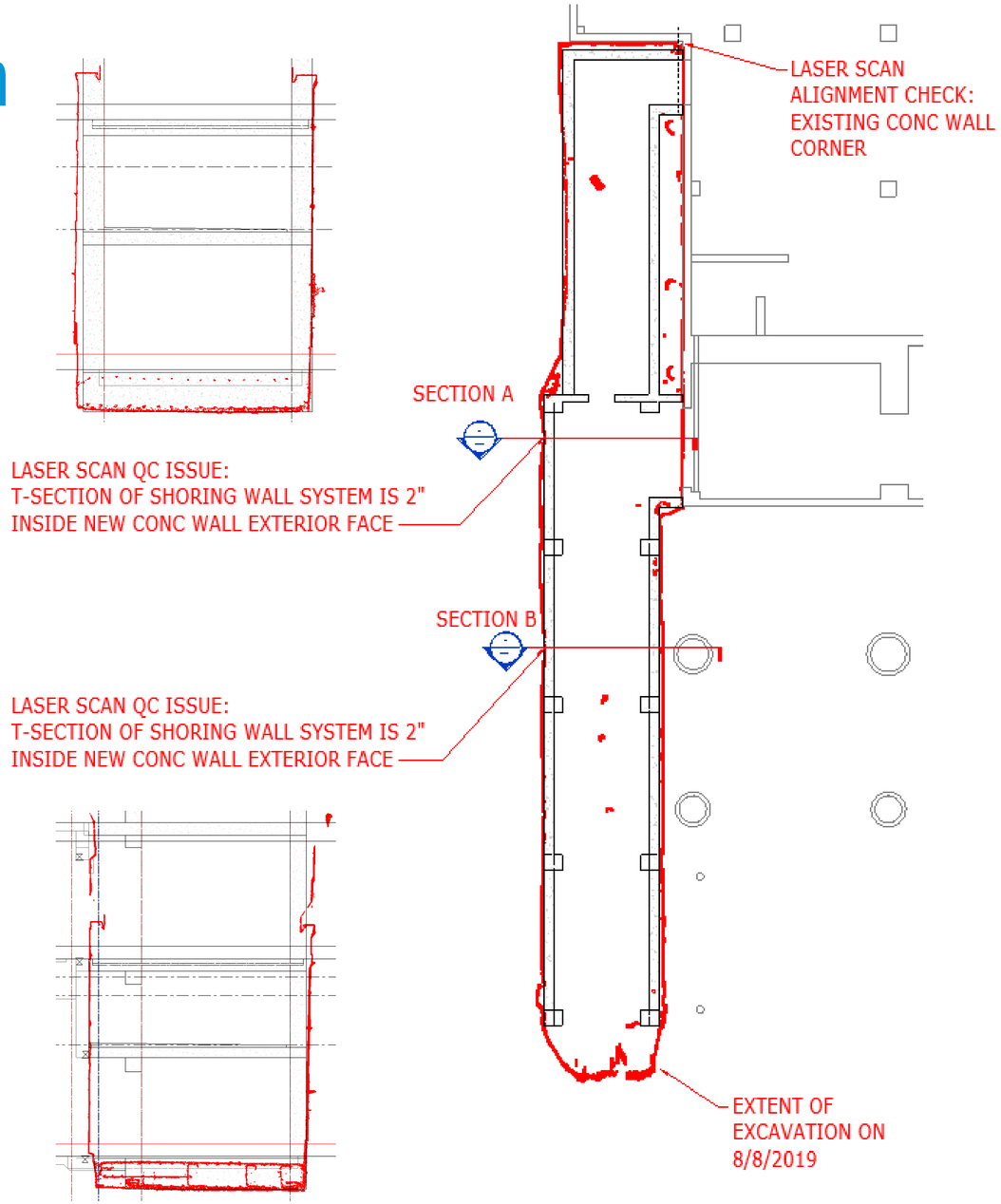
Shoring Alignment Verification

- Identified two locations along shoring system with 2” projection into new concrete wall, compared to over-estimated 4” discrepancy claim by concrete sub
- Shared info with structural engineer, confirmed minor wall thickness reduction, avoiding moving walls or extensive drawing revisions





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Lessons Learned

Verify in Field V. Point Cloud

Necessary to explain scan alignment process and measurement interpretation to stakeholders to ensure shared understanding of quality and impact.

Project Team Communication

Laser scanning on active construction sites requires close coordination with team regarding planning, setup challenges, and time requirements.

Similarity of Applications

Vertical plumbness analysis for elevator or stair shear walls can also be applied to shoring wall systems.

Key Take-Aways

- **Communication:** requires analysis and clearly-explained deliverables
  - Recap files, screenshots, 3D model overlays, 360 photos, and 2D drawings with markups, measurements and annotations.
  - Scan, register and share is not sufficient!
- **Access of the space** = access AND quality of data
- Timing is **everything**
- Don’t be afraid to **think outside the box**!
- It will never be perfect
- Not just pretty pictures