3D Laser Scanning – Pioneering a New Approach to Maximize Contractor & Project Value

Shane Saltzgiver
CEO | Founder
VEC

James Shimamoto
Project Manager
Webcor

Leo Castillo
Director | Reality Capture
VEC

CS227108

AUTODESK. UNIVERSITY

About the speaker

Shane Saltzgiver

Throughout his 15 year career, Mr. Saltzgiver gained broad construction experience during his time spent in Project Management, complementing his mission when he founded the AEC technology solutions company, VEC "Virtual Engineering & Construction." His diverse project experience includes large-scale aviation, transportation and infrastructure projects, the first Public-Private-Partnership (P3) in California, as well as vertical construction projects ranging from high rises in downtown San Francisco to high-end tech projects in Silicon Valley for clients such as Google and Facebook. He has extensive experience in BIM / VDC applications and solving complex engineering and construction problems through innovative technology solutions.

About the speaker

James Shimamoto

Project manager/estimator and licensed CA professional civil engineer in the structural concrete division of a large California-based general contractor. Concrete projects include: high-rise residential (50+ stories), CIP parking garages, structural steel office buildings, CIP hotels, and full design-build public works. Experienced with Autodesk software, but not using regularly in current role. Actively involved in using 3D laser scanning in conjunction with Revit to perform quality control and accuracy of formed and cast-in components of concrete structures.

About the speaker

Leo Castillo

Throughout his 18 year career, Mr. Castillo has been at the forefront of developing 3D design, 3D survey, and 3D construction workflows to benefit project coordination, risk management, and cost control. His diverse experience includes large-scale transportation and master planning efforts, and local community improvement projects. He has extensive experience in 3D & Reality Capture services including BIM, High-Definition Scanning, GIS, & UAV Mapping & Surveying.

Agenda

Part 1: Start with Why

- Idea Inception
- The Problem we Wanted to Solve

Part 2: Case Study

- Project Background
- Risk and Error Associated with Cast-in-Place Structures

Part 3: How to Mitigate this Risk with 3D Laser Scanning

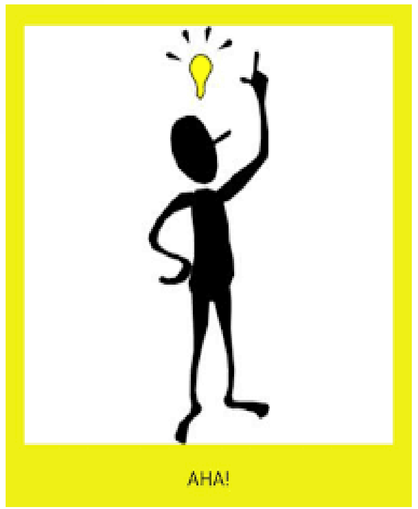
Part 4: The Results

Part 5: Q & A

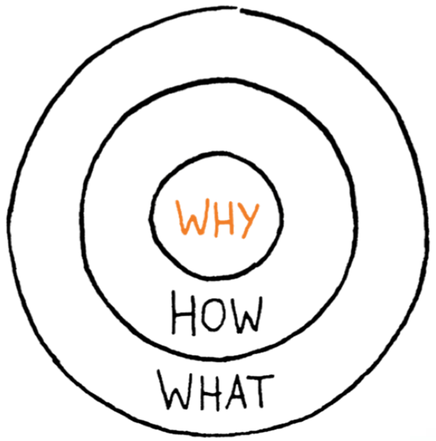
Learning Objectives

1. Learn a repeatable workflow: 3D laser scan, register, compare to BIM model, and produce actionable drawings in less than 24 hours.
2. Understand the step-by-step technical workflow required for implementation.
3. Recognize the challenges and logistics necessary for success.
4. Learn how to mitigate contractor risk and project delays by harnessing 3D laser scan data in new ways.
5. Learn how to save your projects potentially hundreds of thousands of dollars spent on incorrect embeds, concrete forms, MEP inserts, and more.
6. Learn about adopting available software designed to assist with the automatic comparison of 3D laser scans to the BIM models
7. Be able to sell this repeatable process to contractors & owners.

Part 1 - Start with Why



1. Idea Inception
2. The Problem We Wanted To Solve
3. The Potential Value



Part 2 - Case Study

Block 33 – San Francisco, CA

- **Location:** Mission Bay district of San Francisco, across street from new Warriors stadium
- **Use:** New Center for Vision Neuroscience with ophthalmology clinics as well as teaching, research, conference, and administrative space.
- **Structure:**
  - 13 story CIP post-tensioned structure
  - 6 levels of 3 pour areas for total footprint of 45,000 SF (clinical space)
  - 7 levels of 2 pour areas for total footprint of 25,000 SF (office space)
  - 343,000 SF total
- **Project Delivery Method:** Design-Build / IPD
- **Special Design Requirements:**
  - 100 year design life
  - Designed to accommodate sea level rise
  - Able to be repurposed

Post-Tension Concrete Structure

WHY POST-TENSION?

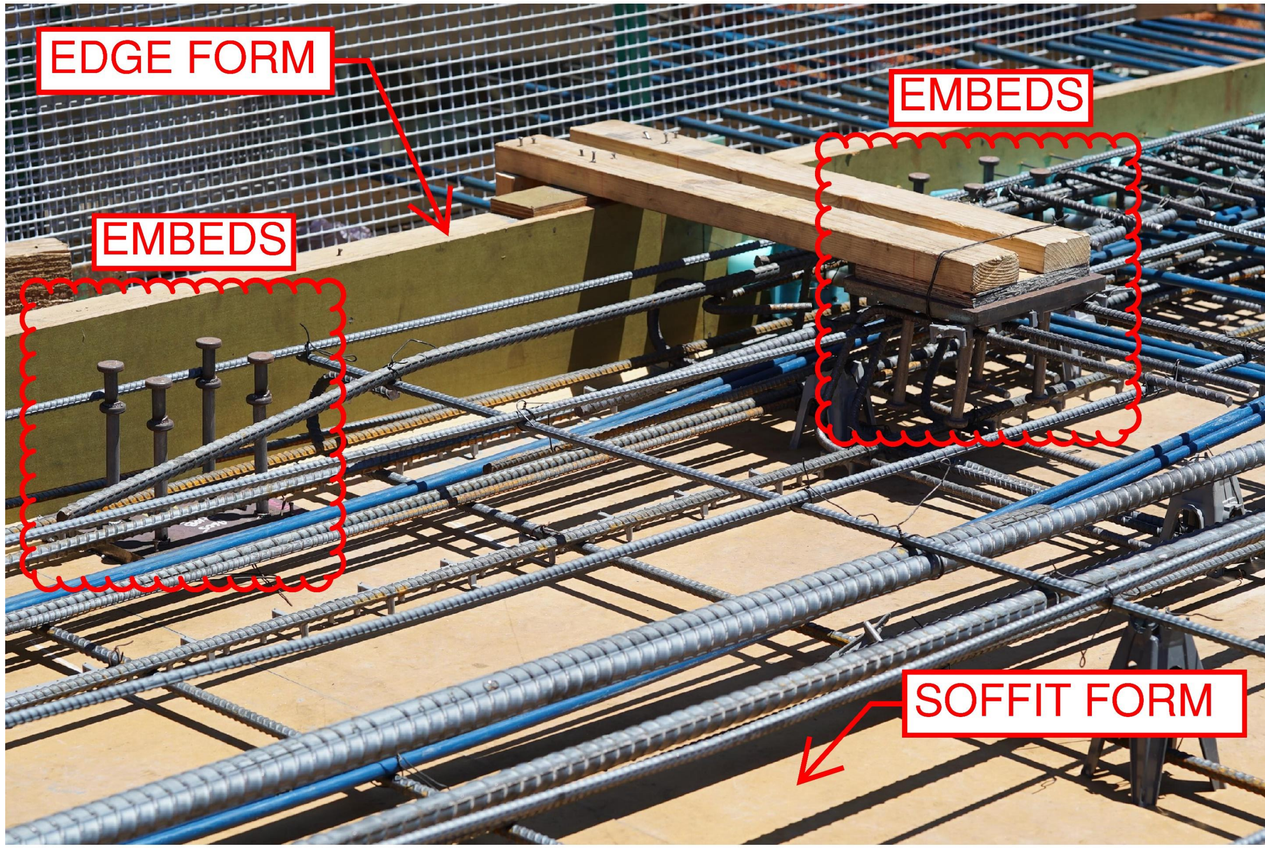
- Design/Build > lots of changes, design as you go
- Structural steel is much harder to modify in field and needs to be pre-fabricated
- Concrete is more flexible with changes
- Design requirements of building would make conventionally reinforced decks too thick

CHALLENGES WITH POST-TENSION

- Slab is under high tensile loads and any penetration of a cable releases a lot of energy that can cause damage, compromise structure, or result in injury
- Embeds, blockouts, and edge form – only one chance to get it right
- Post-installation can be costly and complicated
- # of embeds, sleeves, and inserts is high – chances of one or more misplacements are high. 150-200 embeds per pour.

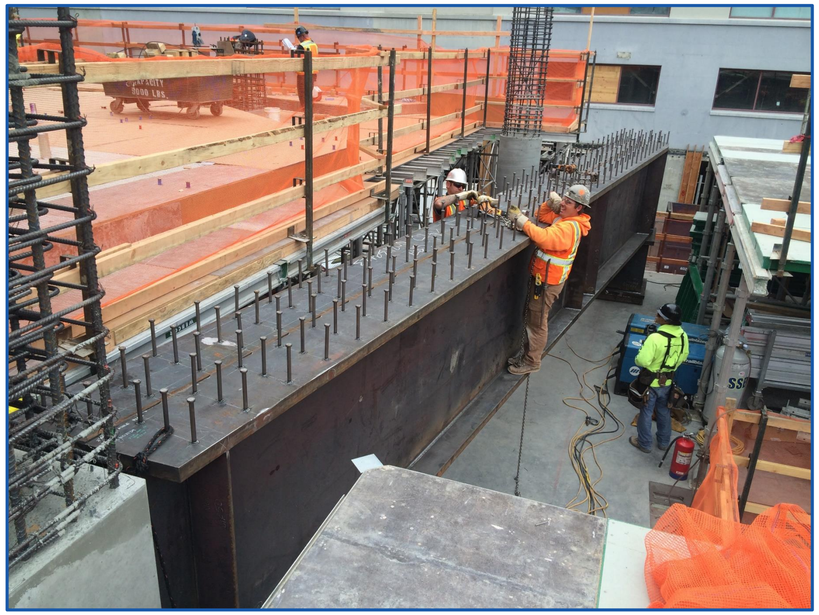
Post-Tension Concrete Structure – Current Practice

- Detailing/Modeling
  - Structural Revit model
  - Superplot, embed, and curb/pad drawings received from other trades
  - 2D shop drawings issued to field
- Embed, Blockout, Edge Form Installation
  - By hand with tape measure
- Pre-Pour Checklist QA/QC
  - Project engineer with tape measure
  - Too many elements to verify accurately
  - Elements can be removed or shifted after checked by PE
- Source of Error – The Risk
  - Incorrect layout
  - Items removed after installation
  - Elements not installed
  - Not checked prior to pour



Consequence of Errors

- Misplaced or Missing Embed
  - Re-engineering, loss of production in installation by other trade, re-work, acceleration costs to make up for delays
- Misplaced Formed Blockouts
  - Example: mechanical duct, stair/elevator opening
  - GPR scan, demo, re-pour, de-tension cables
- Edge Form
  - Creates problems for windows, pre-cast, and other skin systems
- Soffit Elevation
  - Effects framing, door frames



- Direct Cost
  - Re-engineering of system attachment (e.g.: windows, pre-cast, etc.)
  - GPR Scanning for PT Cables
  - Drilling/chipping
  - Welding and/or shimming
- Indirect Cost: (domino effect)
  - Disruption in productive work-flow for other trades
  - Delay to successor activities
  - Acceleration cost to recover from delays
- Historical Data
  - Recent project: $15M Structural Concrete, $500k total direct and indirect cost = 3.5%

Q: How Do You Mitigate This Risk?
A: 3D Laser Scanning

- Originally Planned Scanning and Related BIM
  - The GC already had a contractual obligation to as-built scan and document post-tension cables for future building repurposing without compromising the structure or damaging PT cables.
  - There was 1 day in the schedule for inspection and scanning between completion of rebar and PT cable installation.
  - Webcor Concrete was already developing a BIM model
- So, We Asked Ourselves…
  - Can the scan data and BIM model be compared and reported in an actionable format to the team by 6am the following day, before concrete placement?
- YES!

Part 3 – How We Did It

Project Manager

Designer

Surveyor

Builder/Electrician

What Do They Have In Common?

- Any qualified person can implement BIM & VDC procedures which encompasses high-accuracy digital as-builts through 3D laser scanners

No One
Has a Monopoly
On Measuring

Who Do We Consider Our Competition?

Our Only Competition is the Non-Use of this Technology

Our goal is to serve the industry by promoting, teaching, and sharing our tested and realized success-stories.

Diving In

3D Scanning, Processing, and Many Lessons Learned

Phases/Stages

GUT CHECK

START ASKING QUESTIONS

Is this possible?

What is it going to take to do this?

What are we trying to accomplish?

What is the Tolerance?

What is the Timeframe?

PLANNING

STORYBOARD/DRY-RUN/TESTING

Identify your tools

Identify your specification

Identify ALL Team-members

Identify your constraints/risks

TESTING

DOES IT WORK?

Yes? Sweet!

No? Let’s fix it.

Try, Try Again

EXECUTE

WALK THE WALK

Do It

Work Your Plan

Make Mistakes

Learn, Adapt and Adjust

PPP – Prior Proper Planning

Review the Existing Workflow

- BIM model – structural concrete
- Survey and project coordinates

Meetings with the GC

- How to integrate our process into the construction schedule without impact
- Deliverable expectations and format
- Acceptable tolerances for the comparison
- Set the Contractor expectations and responsibilities

Develop a Theoretical Plan

- Scan plan
- Data transfer plan
- Overnight comparison plan
- Identify potential ways we could fail

Test the Theory – 3X

- MEP Interstitial Space (not time sensitive)
- Slab-on-grade (not in scope) - Twice

24-Hour Breakdown

TIMELINE	ACTIVITY DESCRIPTION
2-Weeks Prior	Layout and mark gridline offset dimensional control intersection points
1-Week Prior	Schedule scan date 1-week prior to scan date (48-hour minimum)
3-Days Prior	Confirm scan inspection date with Webcor Field Team
2-Days Prior	Verify control points have been received and is saved in the project directory with correct naming
4-6am Day of Scan	Mobilize to the site
6-7am	Offload and setup scanning equipment and stretch
7am-3pm	3D Laser Scanning & Diagram setup/control locations
3-5pm	Transfer scan data to local workstation, breakdown, rollup and de-mobilize from project site. Notify remote processing team to login to remote workstation
5-8pm	Remote into remote workstation, process and register 3D laser scans
8-10pm	Export registered scans and import to Autodesk ReCap
10pm-12am	Upload ReCap point cloud to Box Sync folder and notify remote team
12-4am	Visually compare and review the model embed 3D elements against the laser scan and produce the comparison PDF
4-5am	Export the PDF and post to the team Slack channel for QA/QC and peer review
5-6am	Transmit to the Webcor Field Team

SF BAY AREA

BRAZIL

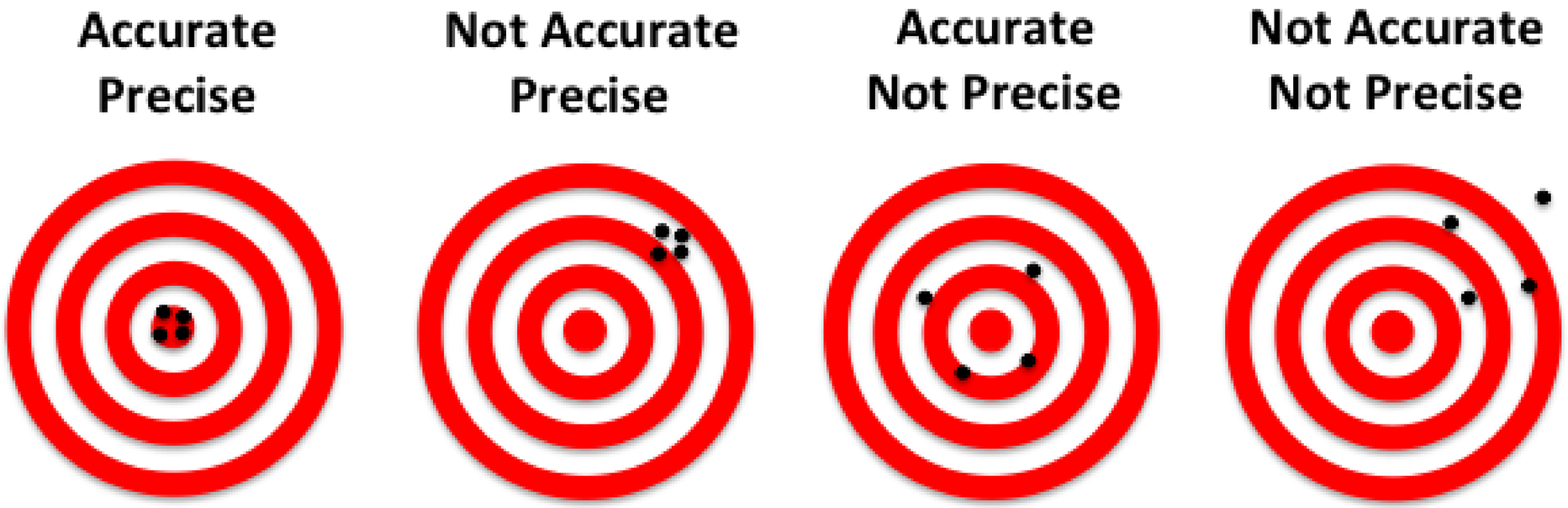
Global Production

Our Toolbelt

EQUIPMENT/PROGRAM	FUNCTION
Autodesk Point Layout	Horizontal & Vertical Control Preparation Software
Leica P40/P50 & RTC360	3D Laser Scanners
Leica Cyclone & Register 360	Laser Scanning Registration Software
Autodesk ReCap/Pro	Point Cloud Conversion Software
CloudCompare	Point Cloud/Model Deviation Software
Autodesk Revit 2017/2018	Deviation Analysis Document Preparation
On-Site Workstation	Reduce Scan Processing and Data Transfer Time

Connecting the Team

EQUIPMENT/PROGRAM	FUNCTION
BIM 360 Design	Distributed Model Editing and Sharing between Field, Office and Remote Users
Teamviewer	Remote and Field screen-sharing
Slack	Real-time communication and file sharing platform
Box	Drive cloud storage and Sync for automated file upload/downloads
Gmail	Cloud communication and transmittal of deliverables to Webcor Field Teams



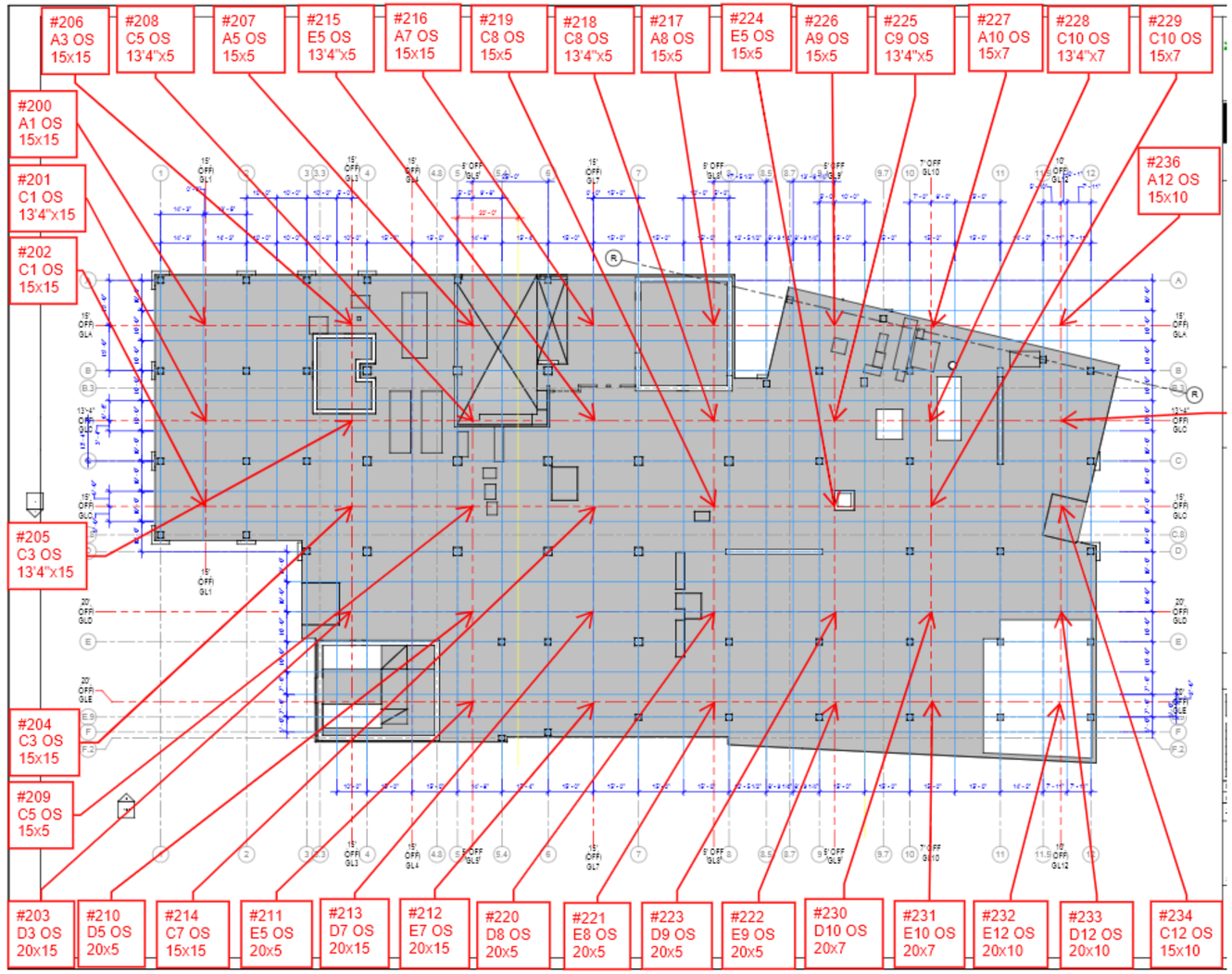
Accuracy

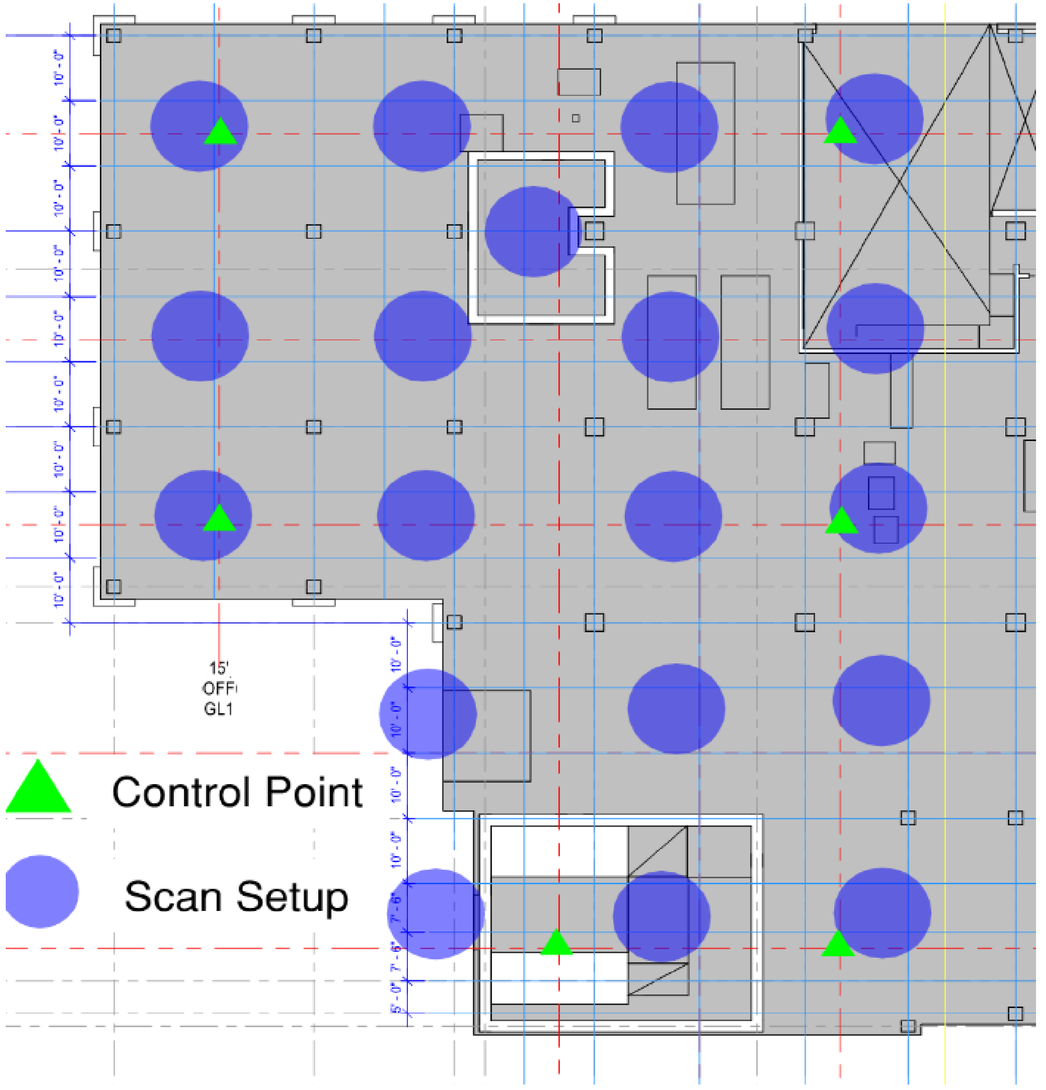
- There are no absolutes
- Error Control
- Calibration

Precision

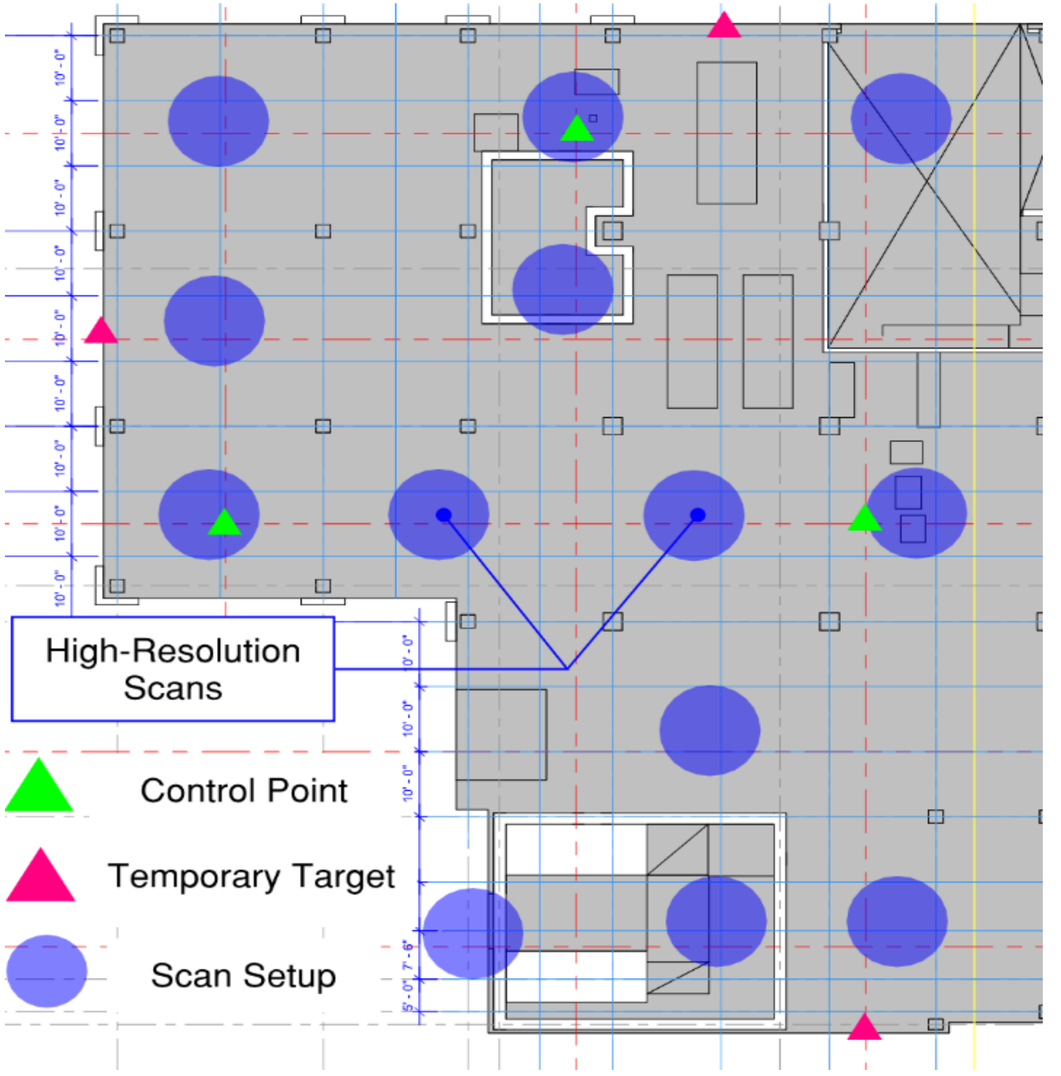
- Consistency & Repeatability
- Discipline & Methodology
- Systemization

Control Overkill

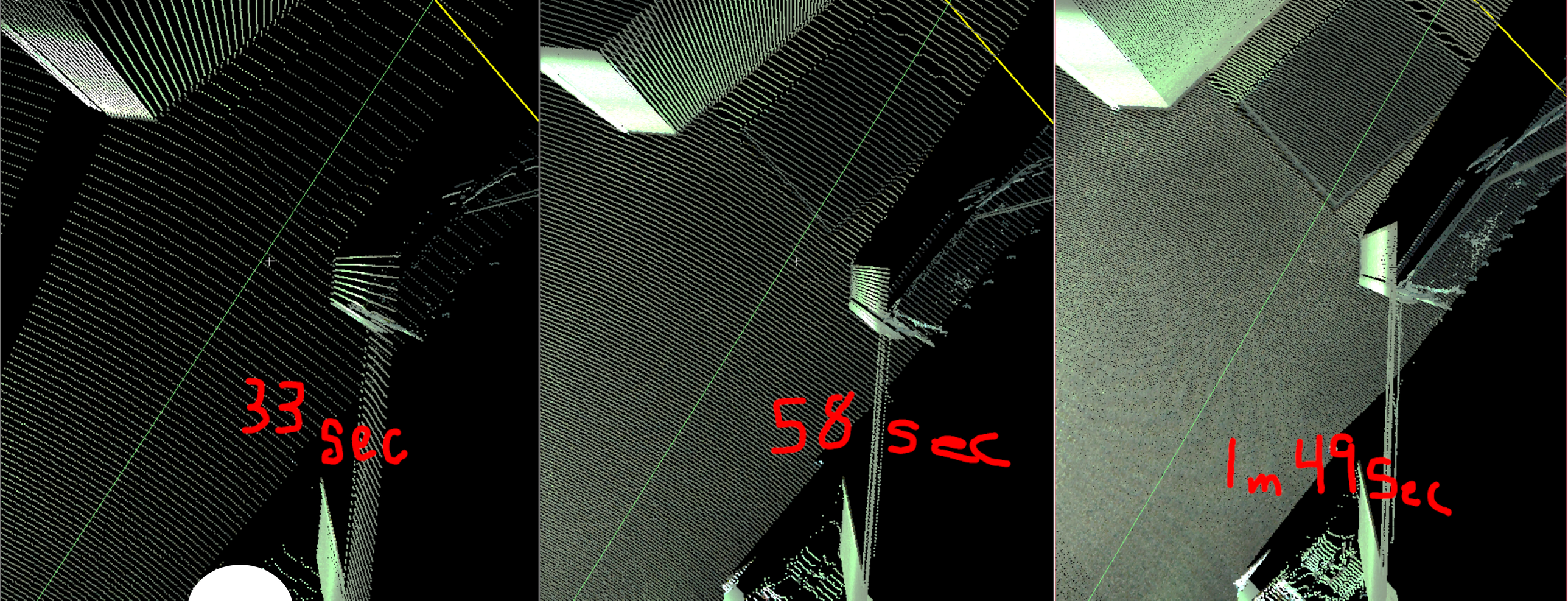




Original Scan Setup Plan



Efficient Scan Setup Plan



Improvement Through Efficient Adaptation

- Can you confidently and reliably obtain the information you need with less data?

Efficiency Gain Facts & Numbers

20	7.5	12	$
SETUP COUNT	MINUTES PER SETUP	HOURS ON-SITE	PROFITABILITY
16	3.0	8	$
25% Improvement	30% Improvement	50% Improvement	Worth It!

Diving In

The Comparison and Report

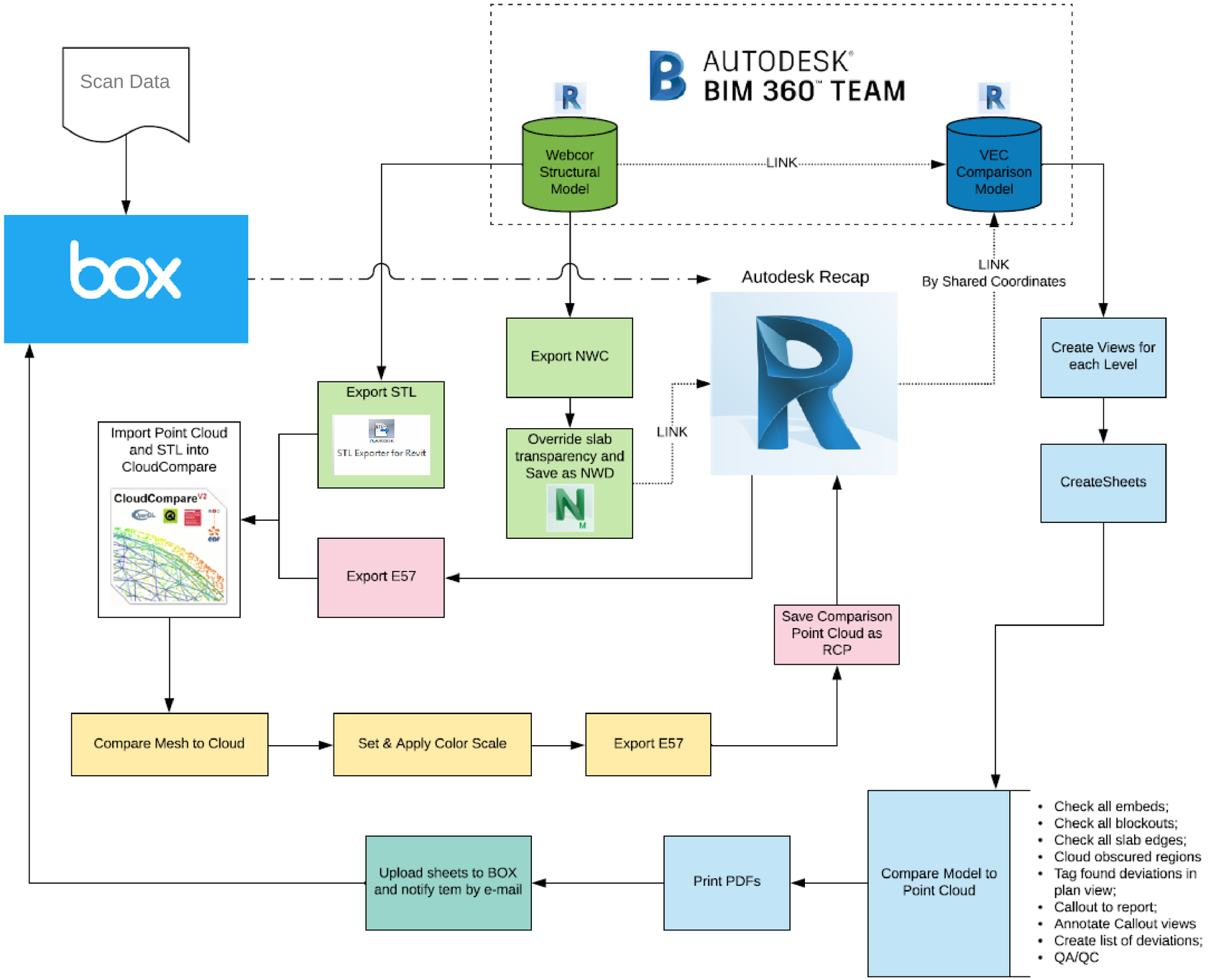
Comparison Workflow

Preparation

- BIM 360 Design – two models
- Export Revit model for automation
- Revit - setup sheets and views
- Verify GC model is updated

It’s Go Time

- Receive point cloud, review in Recap
- Load into Revit and Navisworks and overlay with BIM Model
- Automation: CloudCompare for Soffit
- Manual Comparison:
  - Embeds, Slab Edge Form, Blockouts
- Report all deviations greater than 1”

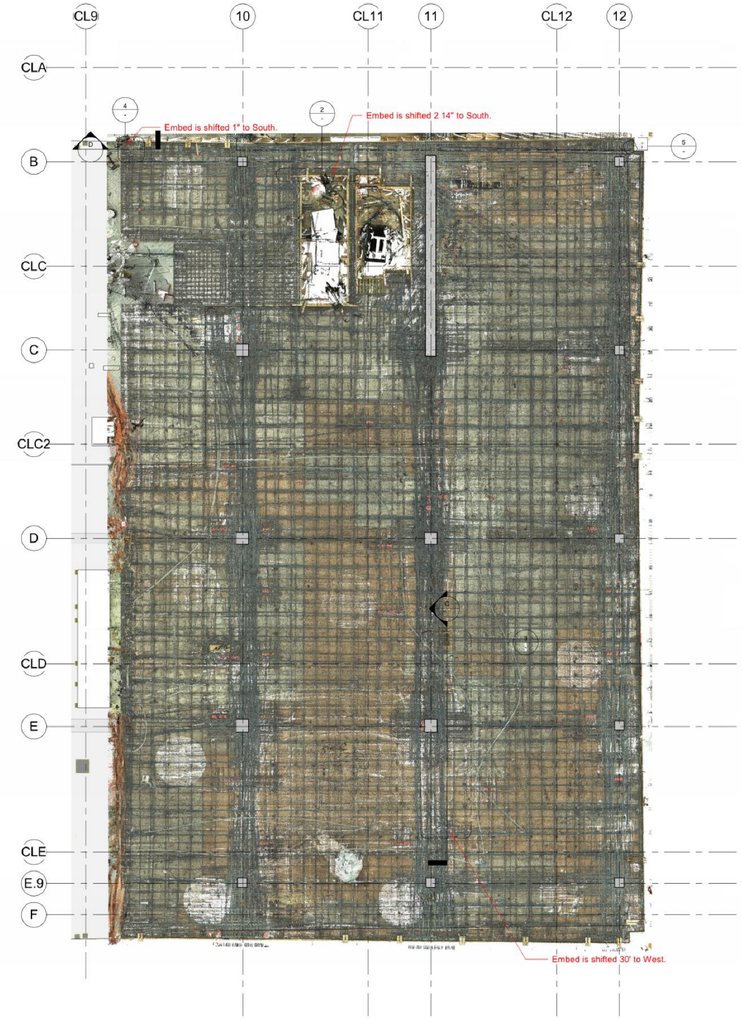


The Deliverable

Criteria

- Deliver (2) actionable drawings by 6am:
  1. Manual Items
  2. Automation
- Report any deviation greater than 1”

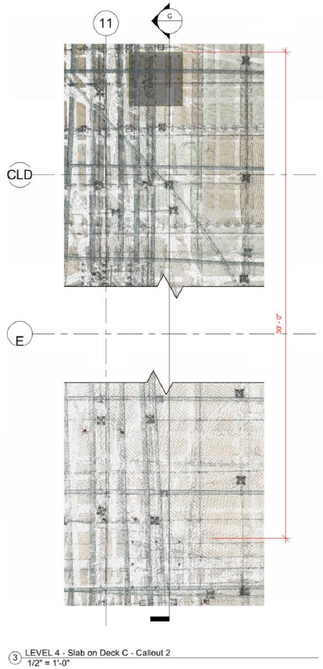
Manual Comparison Report



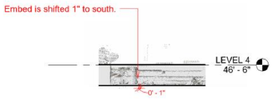
1 LEVEL 4 - Slab on Deck C
1/8" = 1'-0"

Report of Deviations

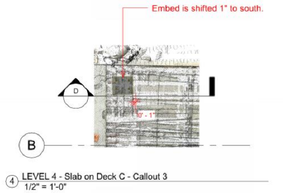
TYPE OF DEVIATION	DESCRIPTION	NUMBER OF ELEMENTS	DEVIATION		NEAREST GRIDS	
			N/S	E/W	VERTICAL	HORIZONTAL
Installed out of tolerance >6"	Embed is shifted 30' to West	1	0'-0"	W 30'-0"	11	CLD
Installed out of tolerance 1" to 6"	Embed is shifted 2 1/4" South	1	S 0'-2 1/4"	0'-0"	CL11	B
Installed out of tolerance 1" to 6"	Embed is shifted 1" to South	1	S 0'-1"	0'-0"	CL9	B



3 LEVEL 4 - Slab on Deck C - Callout 2
1/2" = 1'-0"

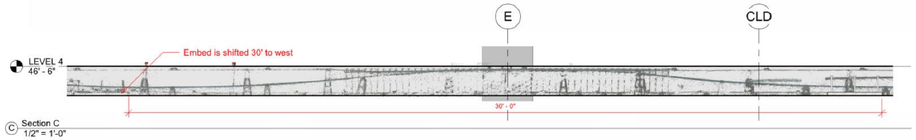


D Section D
1/2" = 1'-0"

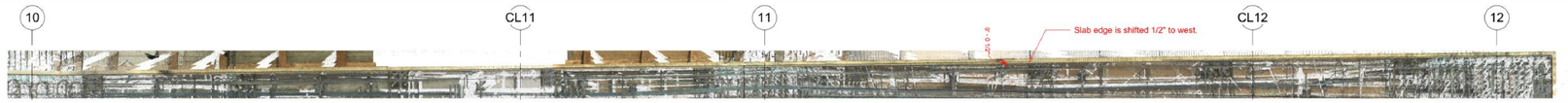


4 LEVEL 4 - Slab on Deck C - Callout 3
1/2" = 1'-0"

2 LEVEL 4 - Slab on Deck C - Callout 1
1/2" = 1'-0"



C Section C
1/2" = 1'-0"



5 LEVEL 4 - Slab on Deck C - Callout 4
1/2" = 1'-0"

NORTH

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VEC

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SAN FRANCISCO, CA 94111
www.VEC-tech.com
(415) 410-3715

SHEET NOTES

1. THE INTENT OF THIS DRAWING IS TO COMPARE THE 3D LASER SCAN OF THE FORMWORK AND EMBEDS OF THE SLAB ON DECK TO THE RESPECTIVE BIM MODELS TO IDENTIFY AREAS THAT DEVIATE FROM THE BIM MODEL. THIS DRAWING SHOULD NOT BE UTILIZED FOR ANY OTHER PURPOSE.
2. CLIENT TO REVIEW ALL COMMENTS AND VERIFY IN FIELD.
3. EXPECTED TOLERANCE: 1/4"-1"
4. 3D SCAN PRECISION: 1/4"
5. 3D LASER SCAN DATA COLLECTED ON 07/02/18
6. CLOUDED AREAS: OBSCURED ELEMENTS. NOT POSSIBLE TO COMPARE.

No.	Description	Date
1		

Webcor Builders

UCSF Block 33

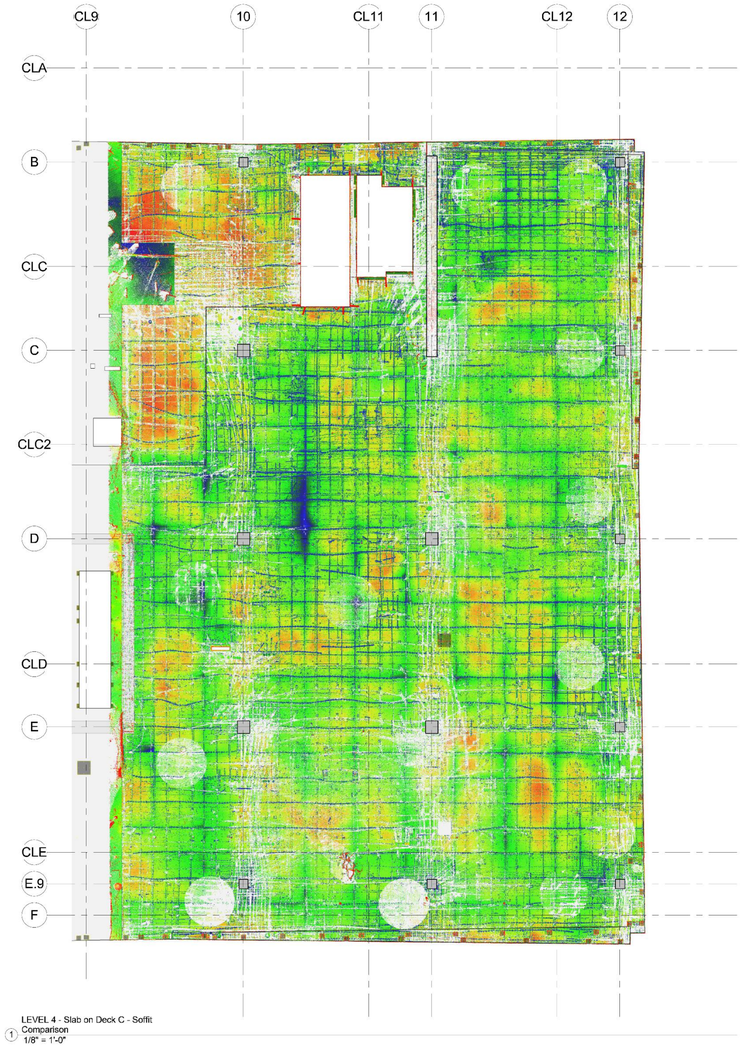
LEVEL 4 SLAB - AREA C - COMPARISON OF 3D LASER SCAN TO BIM MODELS

Project Number	VEC-1801
Date	10/29/2018
Drawn By	WC
Checked By	SS/LRC
Scale	As indicated

L04.C.1

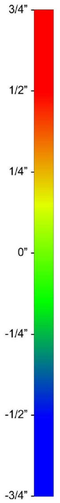
The Deliverable

Automation Comparison Report



1 LEVEL 4 - Slab on Deck C - Soffit Comparison
1/8" = 1'-0"

COLOR SCALE



What did the GC do with this data?

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6. CLOUDED AREAS: OBSCURED ELEMENTS. NOT POSSIBLE TO COMPARE.

No.	Description	Date

Webcor Builders

UCSF Block 33

LEVEL 4 SLAB - AREA C - COMPARISON OF 3D LASER SCAN TO BIM MODELS - SOFFIT COMPARISON

Project Number	VEC-1801
Date	07/03/2018
Drawn By	WC
Checked By	SS/LRC

L04.C.2

Scale 1/8" = 1'-0"

Part 4 – The Results

Reported Deviations Prior to Concrete Placement

Most Significant Findings

- Medical Boom Steel Embed
  - Issue: Embed installed 30’ off in the adjacent bay.
  - Embed Size: 26”x26”x1.5”
- Emergency Exit Stairwell Blockout Form and Embed
  - Issue: Edge Form and embed protruding 6” into stairwell
  - Embed Size: 4’-2” wide x 5” x 5” “L”
- Metal Panel Rain Screen Embed
  - Issue: Embed installed 18” off
  - Embed Size: 10”x10”

Not All Deviations Require Corrective Action

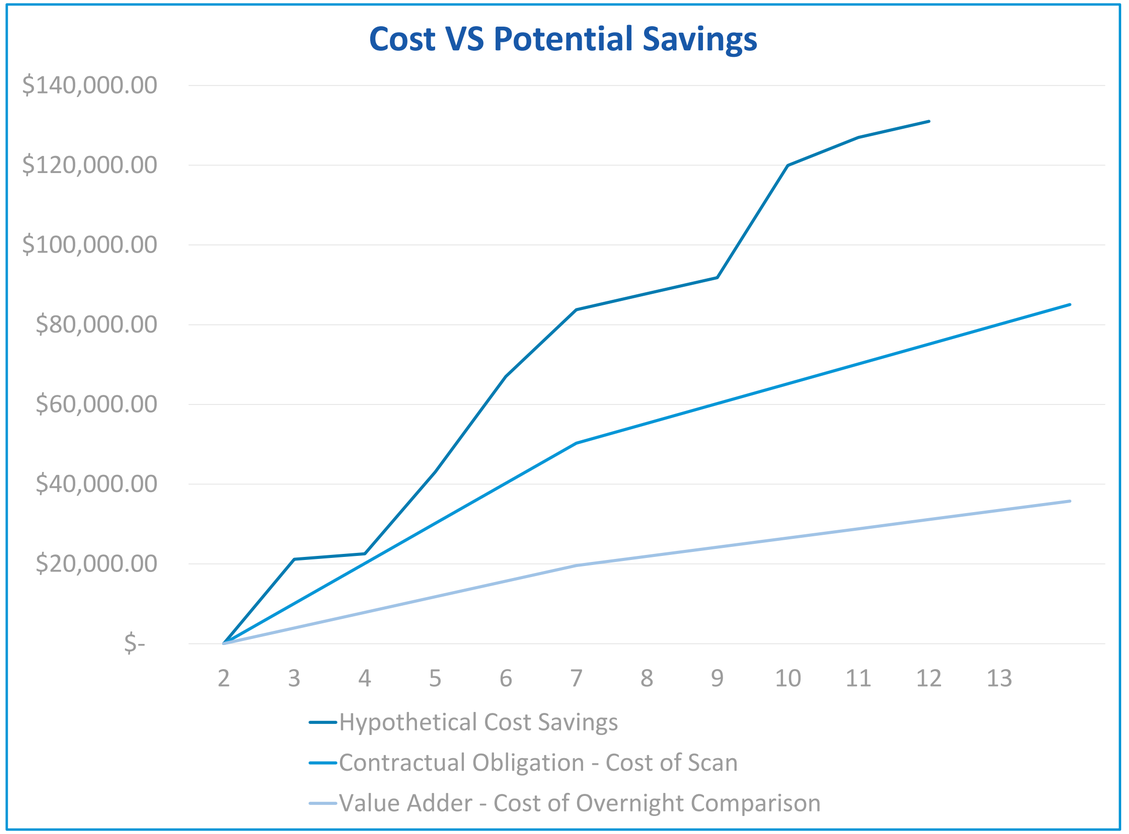
- Field conditions had changed that were not updated in the BIM model
  - Installing different size embeds due to design changes
  - Adding or modifying blockouts
- Deviation is within acceptable tolerance
- BIM Model was missing the component or had additional components

		Embeds				Formwork		
Level	**Area**	**Missing**	**Incorrect Size**	**Deviation 2" to 6"**	**Deviation > 6"**	**Soffit > 1"**	**Edge Form > 1"**	**Blockout >1"**
2	A	0	1	1	2	0	1	0
	B	0	0	1	5	0	0	0
	C	0	1	1	0	0	1	0
3	A	0	0	0	0	0	1	2
	B	0	0	1	0	0	0	1
	C	0	0	0	0	0	0	0
4	A	0	0	3	0	0	1	0
	B	1	0	0	0	0	0	1
	C	0	0	1	1	0	0	0
5	A	0	3	0	0	0	0	0
	B	1	3	3	0	0	0	0
	C	0	0	0	1	0	0	0
6	A	-	-	-	-	-	-	-
	B	2	3	2	0	0	1	0
	C	0	2	0	0	0	0	0
7	A	0	5	0	0	0	0	0
	B	0	0	0	0	0	0	0
8	A	0	5	0	0	0	0	0
	B	-	-	-	-	-	-	-
9	A	4	5	3	0	0	0	0
	B	0	0	0	0	0	0	0
10	A	0	7	1	0	0	0	1
	B	0	0	0	0	0	0	1
11	A	0	5	0	0	0	0	1
	B	0	0	0	0	0	0	0
Totals		8	40	17	9	0	5	7

Potential Direct Cost Savings

Summary of Findings

	Embeds			
	Missing	**Incorrect Size**	**Deviation 2" to 6"**	**Deviation > 6"**
Totals From Table Above	8	40	17	9
Approx. % That Required Corrective Action	75%	15%	25%	50%
Quantity That Required Corrective Action	6	6	4	5
Quantity - Minor Impact	3	4	2	3
Quantity - Moderate Impact	2	2	2	0
Quantity - Major Impact	1	0	0	2
Cost Savings - Minor - $5,000/EA	$ 15,000	$ 20,000	$ 10,000	$ 15,000
Cost Savings - Moderate - $7,500/EA	$ 15,000	$ 15,000	$ 15,000	
Cost Savings - Major - $10,000/EA	$ 10,000			$ 20,000
Subtotal Potential Direct Cost Savings:	$ 40,000	$ 35,000	$ 25,000	$ 35,000
Total Potential Direct Cost Savings:	**$ 135,000**			



And this is only the Direct Cost. The Indirect Cost could be just as high or higher…

Closing Remarks

Q & A

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