Walk-in Slide: AU 2014 Social Media Feed

1. Click on the link below, this will open your web browser

http://aucache.autodesk.com/social/visualization.html

2. Use “Extended Display” to project the website on screen if you plan to work on your computer. Use “Duplicate” to display same image on screen and computer.

Adopting Reality Computing for Plant Design

Scott Diaz, kubit USA, Inc.
John Bunn, kubit USA, Inc.

@kubitUSA

Guest Speakers:
Rod Kriess, Performance Mechanical, Inc.
Eric Kirsch, Jacobs Engineering
Aaron Hunt, TruePoint Scanning, LLC

Class summary

This class will examine real Autodesk user experiences in implementing point cloud data for plant design. This class will also recommend favorable workflows for bringing reality data to Plant Design 2015 software.

Key learning objectives

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

- Learn how to adopt point cloud workflows within the 2015 Plant Design Suite software
- Gain insight from user experiences regarding what to expect with the new Autodesk technology
- Understand the recommended steps for preparing laser scan projects within your Autodesk design package
- Discover how to extract typically needed plant deliverables from point clouds; such as intelligent models, tie-ins and more

Agenda

- Define Reality Computing
- Bring Reality Data to Autodesk 2015
- **Case Study: From scan, to model, to fab**
- Piping and structural extraction techniques
- **Case Study: Reducing turnaround time with reality computing**
- Tie-in point and clash detection techniques
- **Case Study: Equipment Analysis**
- Deformation and volumetric analysis techniques

What is Reality Computing for the Plant Design world?

Capture, Compute, Create

Reality Computing: The process of capturing real world objects to a digital environment, computing and converting the objects to a useful model and using the model to create new, physical objects

CAPTURE for Plant

"Collecting existing field conditions via surveying devices"

- Traditional devices
  - Terrestrial laser scanners

Laser scanner FARO Focus X330

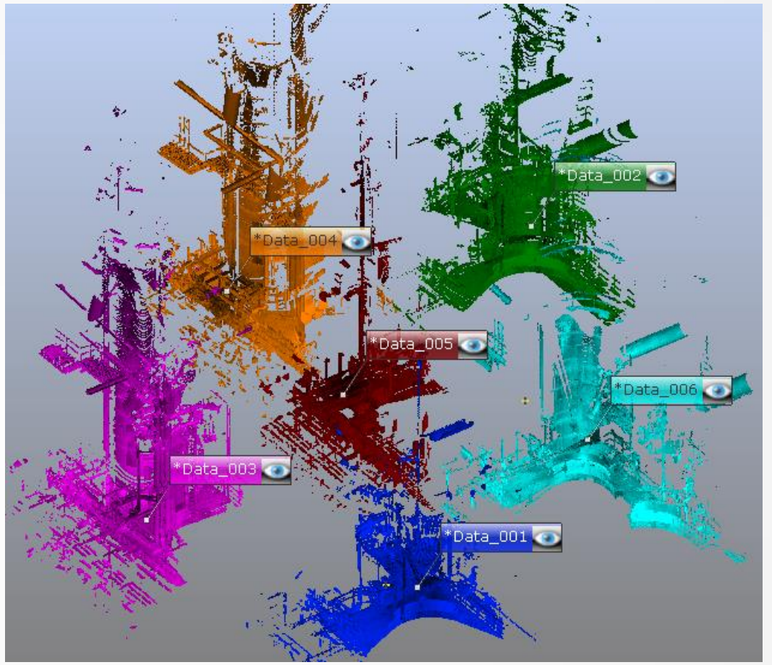
- What's new?
  - Handheld scanners
  - Multi-view photogrammetry
  - Structure from Motion

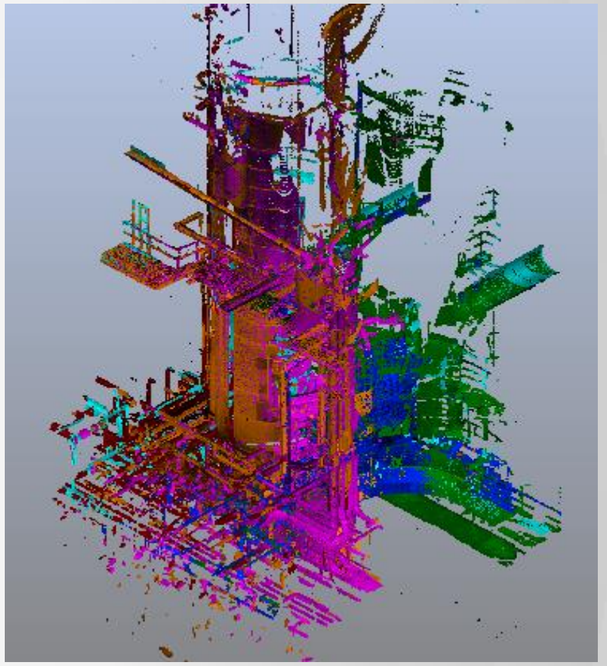
DotProduct DPI-7 Handheld 3D Imager

COMPUTE for Plant

"Processing captured data into a useful form"

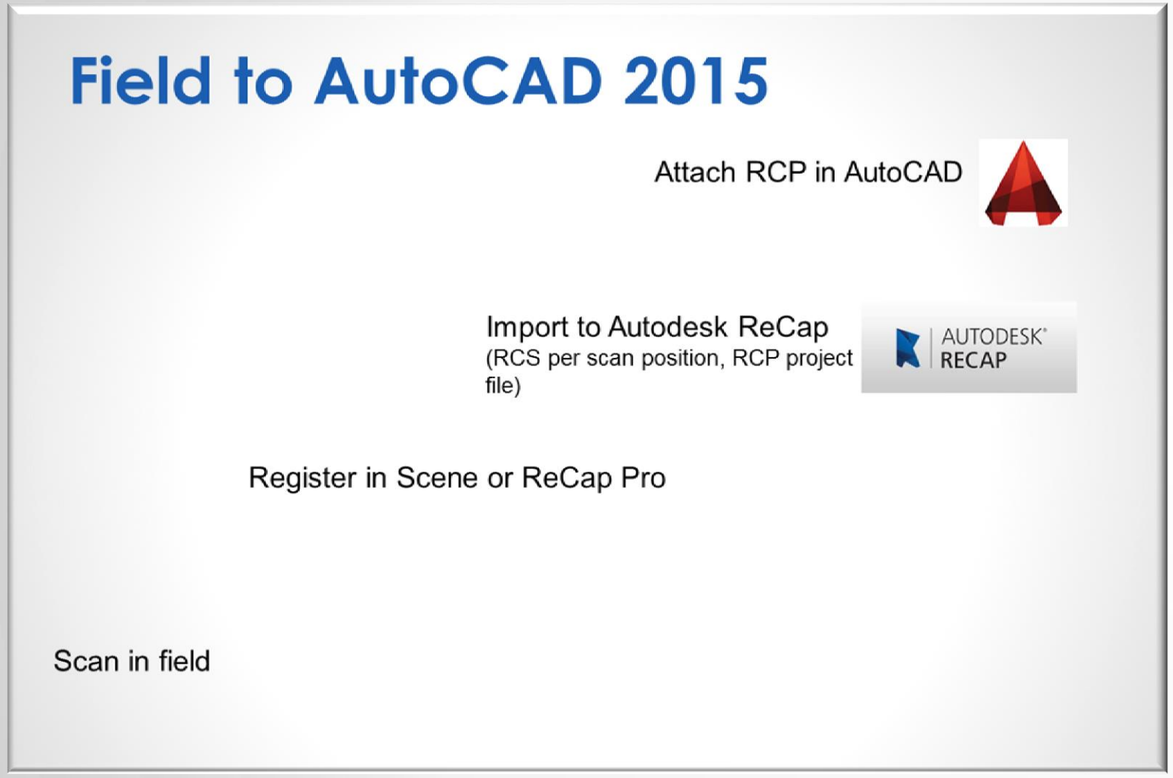
- Registration
  - Bringing individual scans into organized coordinate system
  - Cleaning/filtering noise





COMPUTE for Plant

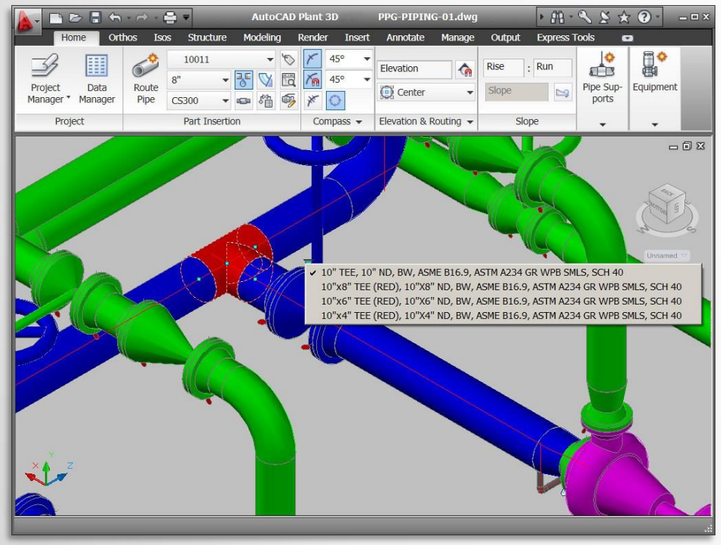
"Processing captured data into a useful form"



- Post-processing
  - Bringing data to Autodesk and AutoCAD
  - Converting data to usable form
    - Models
    - Analysis/reports

CREATE for Plant

- Create Deliverables
  - Intelligent models
  - Isometrics



- Fabricate
  - New plant installation
  - Identify and repair in field

From field to CAD:
Bringing Reality Data to Autodesk 2015

Field to AutoCAD 2015

Attach RCP i CAD

3

2

Import to Autodesk ReCap
(RCS per scan position, RCP project file)

AUTODESK® RECAP

All
organ

1

Register in manufacturer's software or ReCap Pro

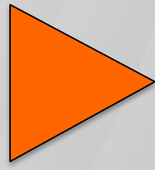
4

5

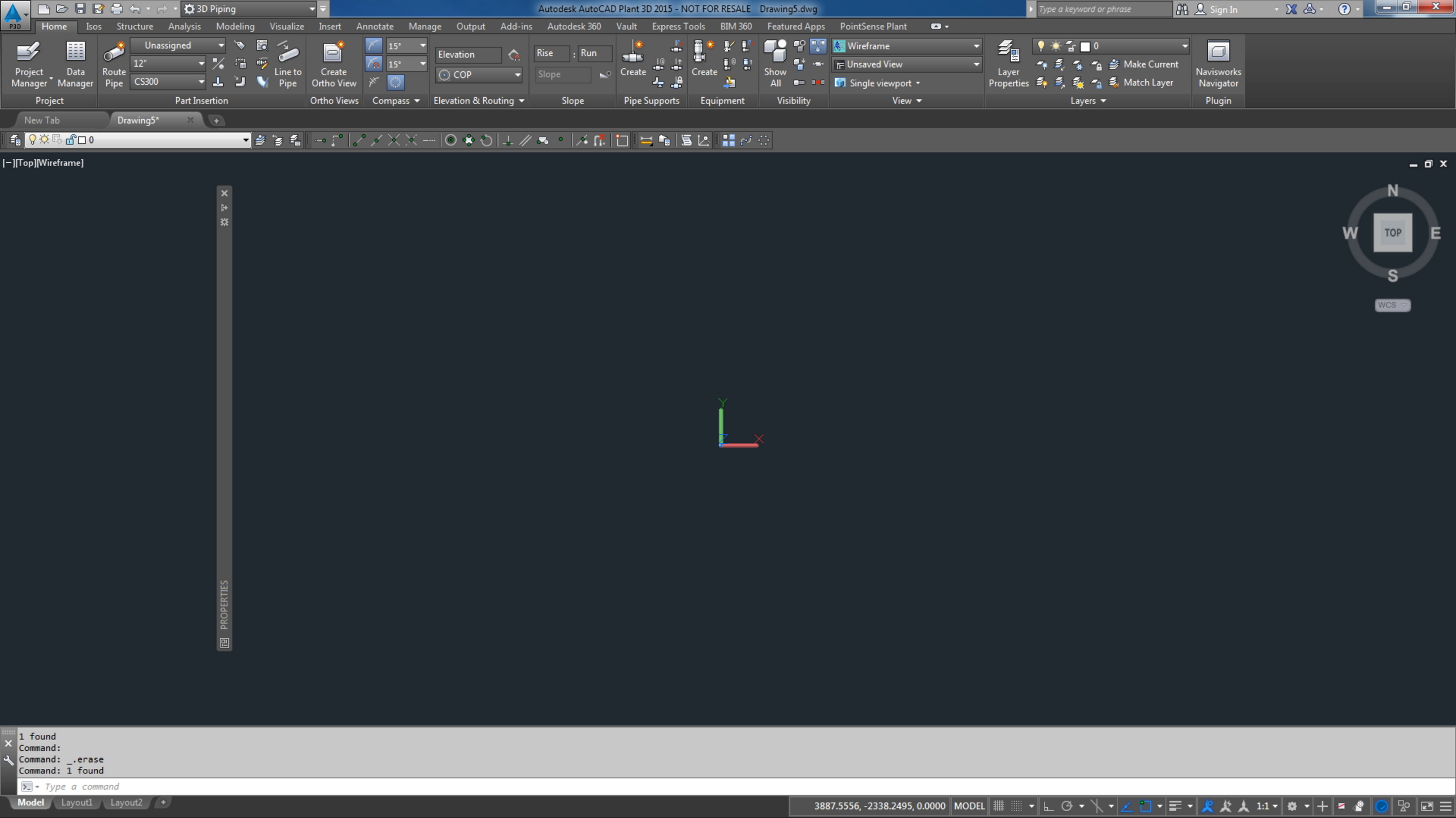
Scan in field

AutoCAD 2015: What's New

- Improved Graphics
  - Larger point clouds at higher density
  - Adjustable point size
  - Higher point max
- RCP/RCS Files
  - PCG legacy support only
- 64 bit only and quality graphics card
- Point Cloud Manager
  - Turns scans on/off
  - Isolating scan positions improves view quality




AUTODESK®
RECAP
AUTODESK.


3D Piping
Autodesk AutoCAD Plant 3D 2015 - NOT FOR RESALE Drawing5.dwg
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Add-ins
Autodesk 360
Vault
Express Tools
BIM 360
Featured Apps
PointSense Plant
Project Manager
Data Manager
Project
Route Pipe
Unassigned
12"
CS300
Line to Pipe
Part Insertion
Create Ortho View
Ortho Views
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Compass
Elevation
COP
Elevation & Routing
Rise
Run
Slope
Create
Pipe Supports
Create
Equipment
Show All
Visibility
Wireframe
Unsaved View
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View
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Layout2
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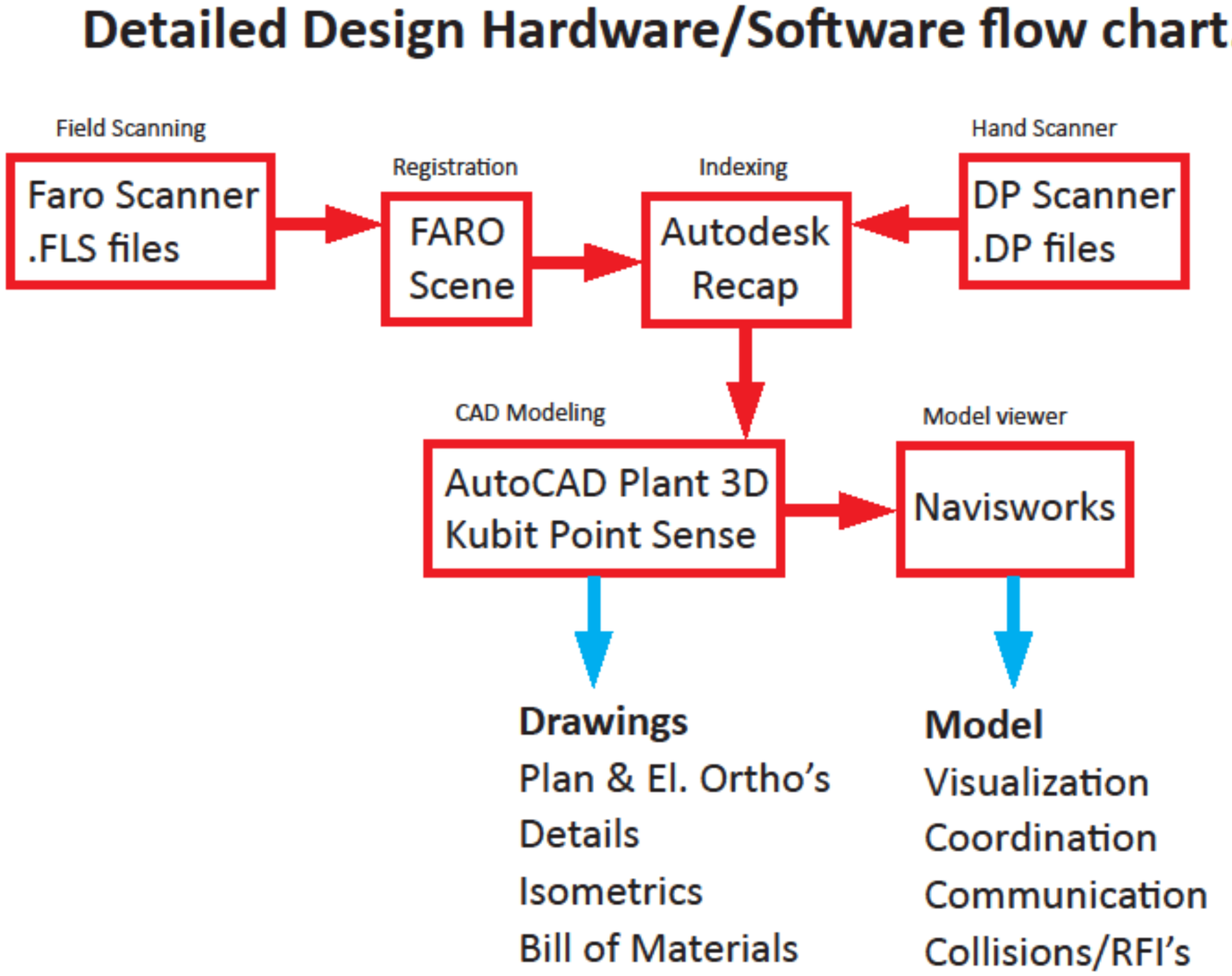
MODEL
1:1

User Experience:
From Scan, to Model, to Fabrication

Rod Kreiss: Background and Bio

- Detailing Manager, Performance Mechanical, Inc.
  - 16 Years.
- Performance Mechanical, Inc.
  - Heavy Industrial Mechanical contractor.
  - Refineries, Power Plants, Chemical Plants.
- Began using AutoCAD point clouds in 2009
  - Several hundred successful scan jobs.

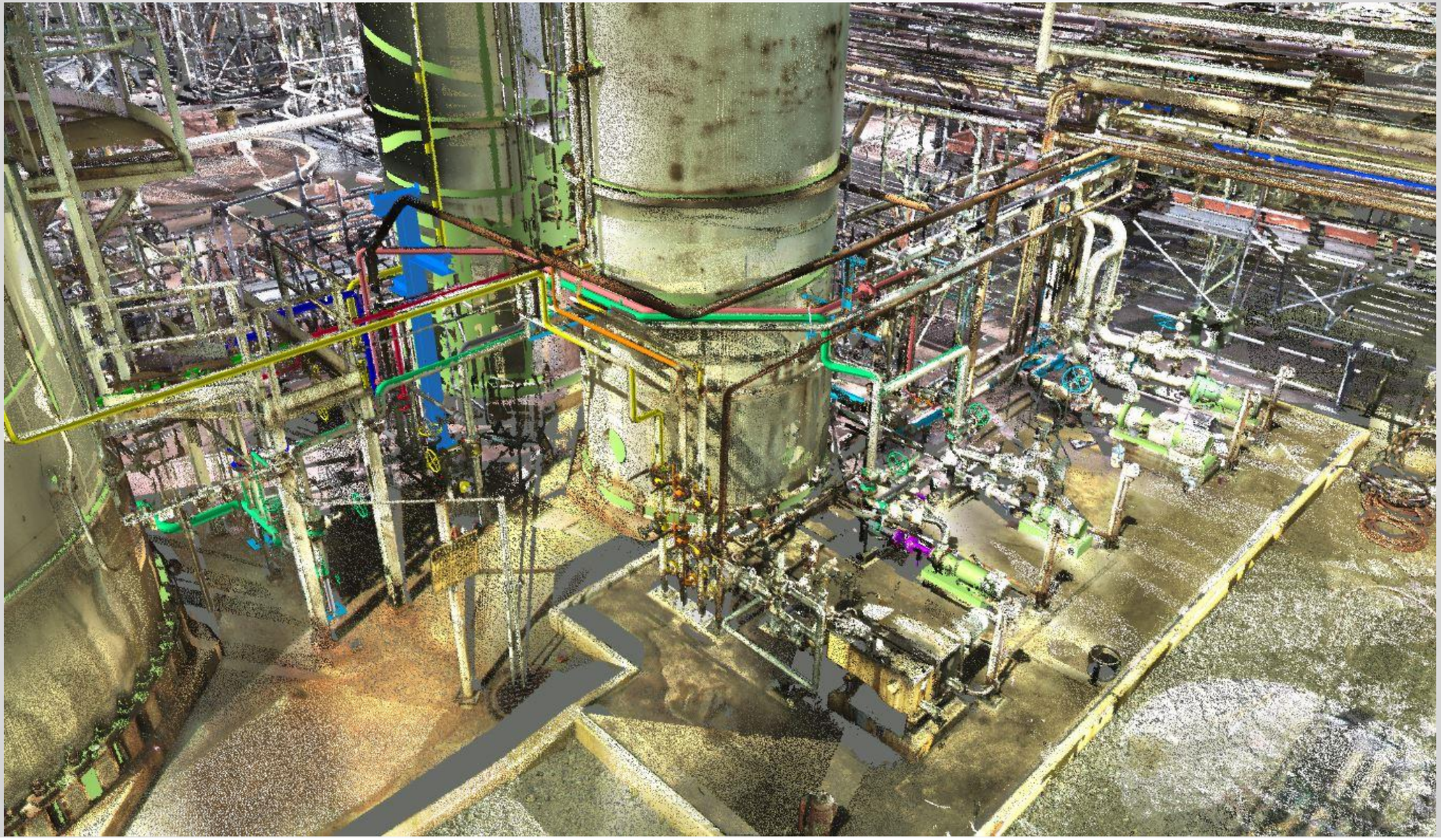
Software used



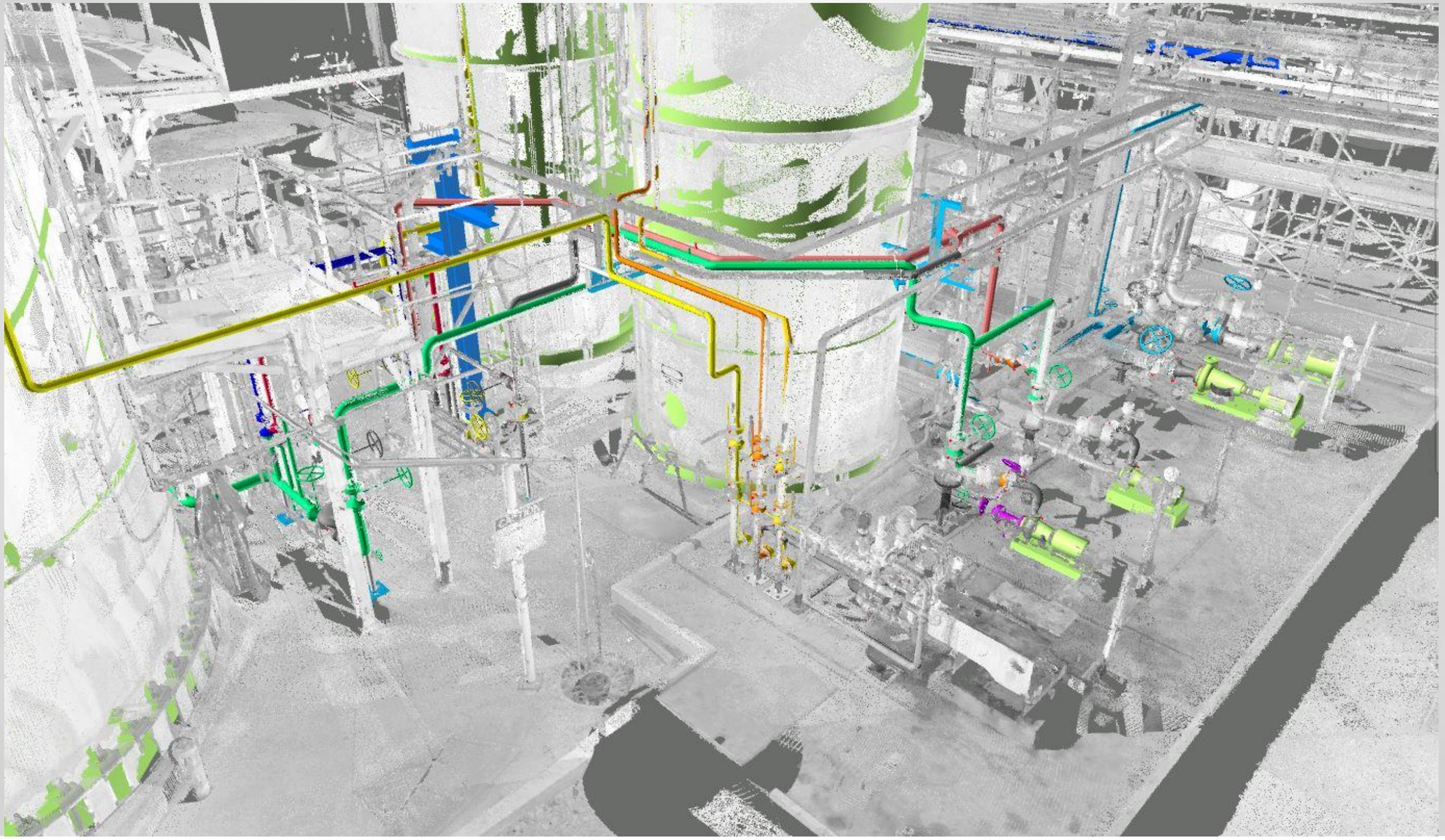
Advantages to scanning

- “Detailed” Design
  - Design something that can be installed, minimizing rework.
  - Collision free within an existing environment.
- Fabricate more, to a higher level of accuracy
  - Shift field labor hours to the shop, reduced install time.
  - More productive and safer environment.
- Reduced design time
  - Design more accurately and faster.

Project Screenshot



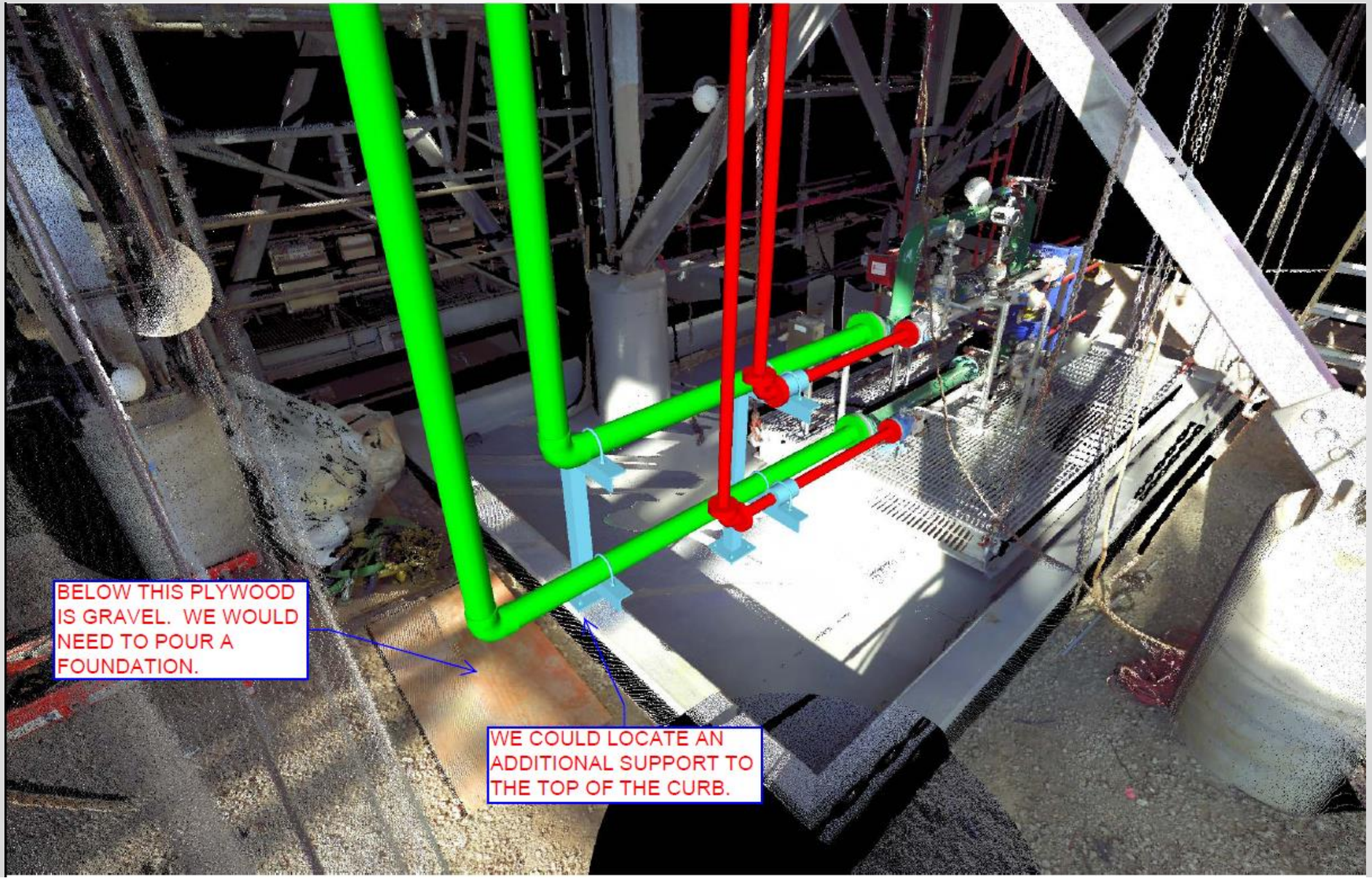
Project Screenshot



Challenges

- Working in live plant environment
  - Low energy hot work permits.
  - Limited access to some areas.
  - Other contractors/personnel working in the same area.
- Scaffolding and other obstructions
  - Blocks views of what needs to be scanned.
- Vertical scan jobs & large area scans
  - Columns and vertical vessels, Tank farms.
- Software/hardware limitations

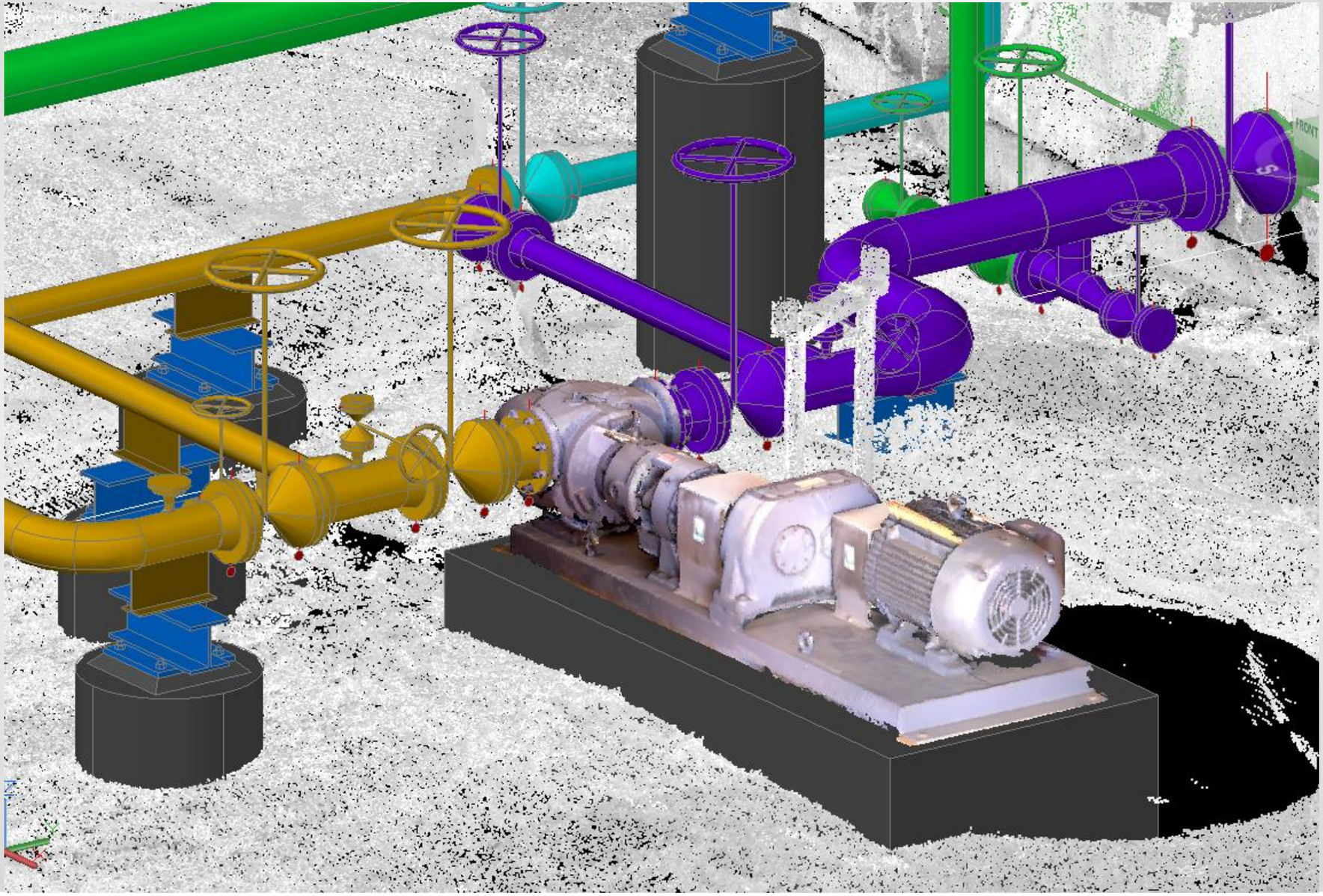
Project Screenshot



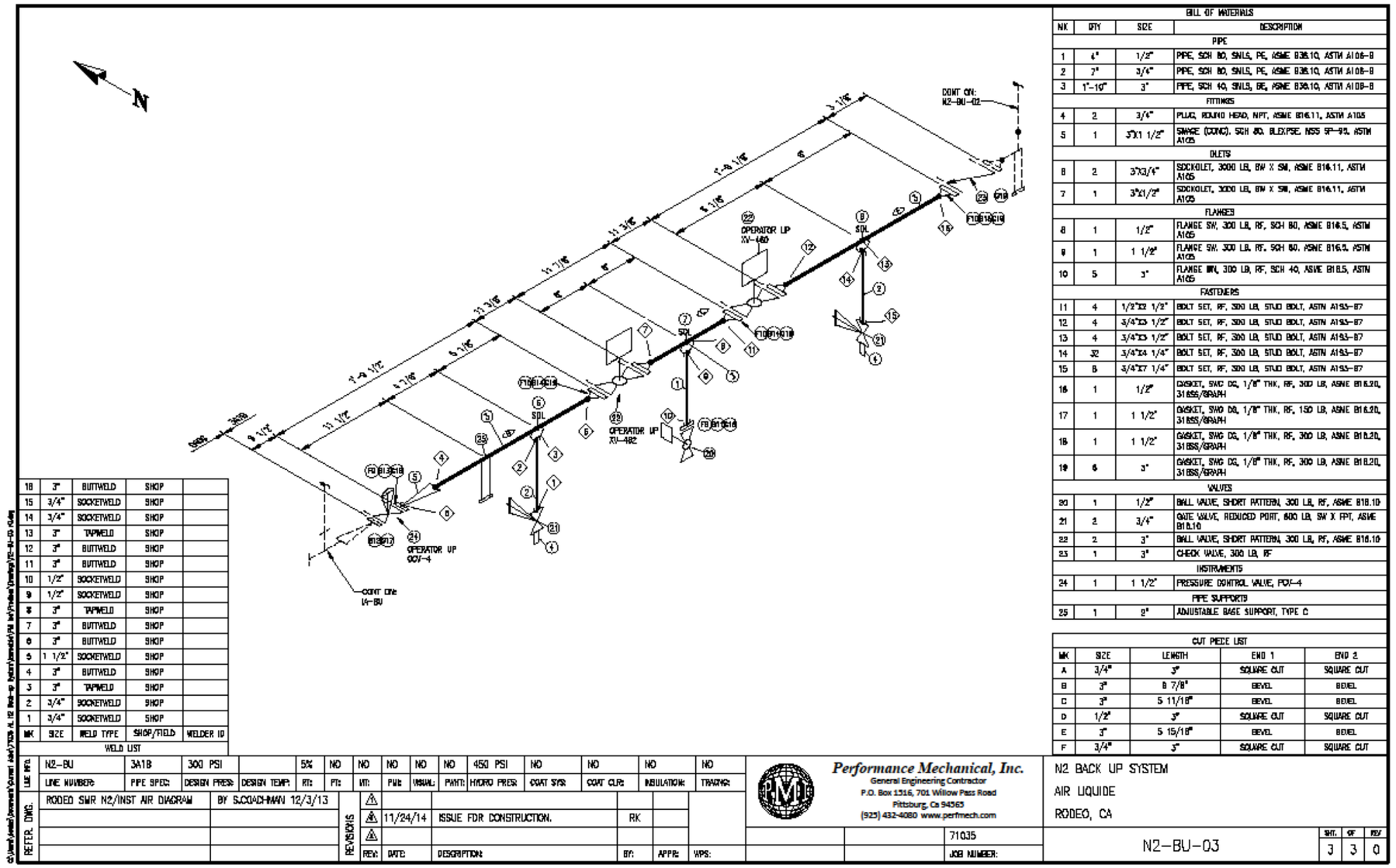
Overcoming challenges

- Get in early
  - Prior to scaffolds and other contractors.
  - Project managers are becoming more aware of scanning needs.
- Utilize service providers, F3 & Associates
  - For large scan jobs.
- Software/hardware
  - The software is making leaps and bound each year.
  - Stay current with the latest versions of software.
  - Spend the money on the right computer.

Project Screenshot



Project Screenshot



BILL OF MATERIALS			
MK	QTY	SIZE	DESCRIPTION
PIPE			
1	4'	1/2"	PIPE, SCH 80, SMLS, PE, ASME B36.10, ASTM A106-B
2	7'	3/4"	PIPE, SCH 80, SMLS, PE, ASME B36.10, ASTM A106-B
3	1'-10"	3"	PIPE, SCH 40, SMLS, BE, ASME B36.10, ASTM A106-B
FITTINGS			
4	2	3/4"	PLUG, ROUND HEAD, NPT, ASME B16.11, ASTM A105
5	1	3"X1 1/2"	SWAGE (CONC), SCH 80, BLEXPSE, NSS SP-95, ASTM A105
OLETS			
6	2	3"X3/4"	SOCKOLET, 3000 LB, BW X SW, ASME B16.11, ASTM A105
7	1	3"X1/2"	SOCKOLET, 3000 LB, BW X SW, ASME B16.11, ASTM A105
FLANGES			
8	1	1/2"	FLANGE SW, 300 LB, RF, SCH 80, ASME B16.5, ASTM A105
9	1	1 1/2"	FLANGE SW, 300 LB, RF, SCH 80, ASME B16.5, ASTM A105
10	5	3"	FLANGE BW, 300 LB, RF, SCH 40, ASME B16.5, ASTM A105
FASTENERS			
11	4	1/2"X2 1/2"	BOLT SET, RF, 300 LB, STUD BOLT, ASTM A193-B7
12	4	3/4"X3 1/2"	BOLT SET, RF, 300 LB, STUD BOLT, ASTM A193-B7
13	4	3/4"X3 1/2"	BOLT SET, RF, 300 LB, STUD BOLT, ASTM A193-B7
14	32	3/4"X4 1/4"	BOLT SET, RF, 300 LB, STUD BOLT, ASTM A193-B7
15	8	3/4"X7 1/4"	BOLT SET, RF, 300 LB, STUD BOLT, ASTM A193-B7
16	1	1/2"	GASKET, SWG CG, 1/8" THK, RF, 300 LB, ASME B16.20, 316SS/GRAPH
17	1	1 1/2"	GASKET, SWG CG, 1/8" THK, RF, 150 LB, ASME B16.20, 316SS/GRAPH
18	1	1 1/2"	GASKET, SWG CG, 1/8" THK, RF, 300 LB, ASME B16.20, 316SS/GRAPH
19	6	3"	GASKET, SWG CG, 1/8" THK, RF, 300 LB, ASME B16.20, 316SS/GRAPH
VALVES			
20	1	1/2"	BALL VALVE, SHORT PATTERN, 300 LB, RF, ASME B16.10
21	2	3/4"	GATE VALVE, REDUCED PORT, 800 LB, SW X FPT, ASME B16.10
22	2	3"	BALL VALVE, SHORT PATTERN, 300 LB, RF, ASME B16.10
23	1	3"	CHECK VALVE, 300 LB, RF
INSTRUMENTS			
24	1	1 1/2"	PRESSURE CONTROL VALVE, PCV-4
PIPE SUPPORTS			
25	1	8"	ADJUSTABLE BASE SUPPORT, TYPE C

CUT PIECE LIST				
MK	SIZE	LENGTH	END 1	END 2
A	3/4"	3"	SQUARE CUT	SQUARE CUT
B	3"	8 7/8"	BEVEL	BEVEL
C	3"	5 11/16"	BEVEL	BEVEL
D	1/2"	3"	SQUARE CUT	SQUARE CUT
E	3"	5 15/16"	BEVEL	BEVEL
F	3/4"	3"	SQUARE CUT	SQUARE CUT

WELD LIST					
MK	SIZE	WELD TYPE	SHOP/FIELD	WELDER ID
18	3"	BUTTWELD	SHOP	
15	3/4"	SOCKETWELD	SHOP	
14	3/4"	SOCKETWELD	SHOP	
13	3"	TAPWELD	SHOP	
12	3"	BUTTWELD	SHOP	
11	3"	BUTTWELD	SHOP	
10	1/2"	SOCKETWELD	SHOP	
9	1/2"	SOCKETWELD	SHOP	
8	3"	TAPWELD	SHOP	
7	3"	BUTTWELD	SHOP	
6	3"	BUTTWELD	SHOP	
5	1 1/2"	SOCKETWELD	SHOP	
4	3"	BUTTWELD	SHOP	
3	3"	TAPWELD	SHOP	
2	3/4"	SOCKETWELD	SHOP	
1	3/4"	SOCKETWELD	SHOP	

LINE NO.	PIPE SPEC:	DESIGN PRESS:	DESIGN TEMP:	RT:	PT:	MT:	PWHT:	VISUAL:	PWHT:	HYDRO PRES:	COAT SYS:	COAT CLR:	INSULATION:	TRACING:
N2-BU	3A1B	300 PSI		5%	NO	NO	NO	NO	NO	450 PSI	NO	NO	NO	NO

REFER. DWG.: RODEO SWR N2/INST AIR DIAGRAM — BY S.COACHMAN 12/3/13

REVISIONS				
REV:	DATE:	DESCRIPTION:	BY:	APPR:	WPS:
1	11/24/14	ISSUE FOR CONSTRUCTION.	RK		

Performance Mechanical, Inc.
General Engineering Contractor
P.O. Box 1316, 701 Willow Pass Road
Pittsburg, Ca 94565
(925) 432-4080 www.perfmech.com

JOB NUMBER: 71035

N2 BACK UP SYSTEM
AIR LIQUIDE
RODEO, CA

N2-BU-03

SHT.	OF	REV
3	3	0

Summary

- Hardware/Software
  - Faro Focus 3D, Dot Product hand held scanner.
  - Faro Scene, Autodesk Recap.
  - 2015 Autodesk Plant Design Suite Premium.
  - Kubit PointSense Plant.
  - Alienware laptops, i7 processor, 16 GB of ram, SSD hard drives.
- Shop fab more, spend less time in the field
  - Minimize rework, this is the main cost saving for us.
  - Scanning is starting to affect our estimates.

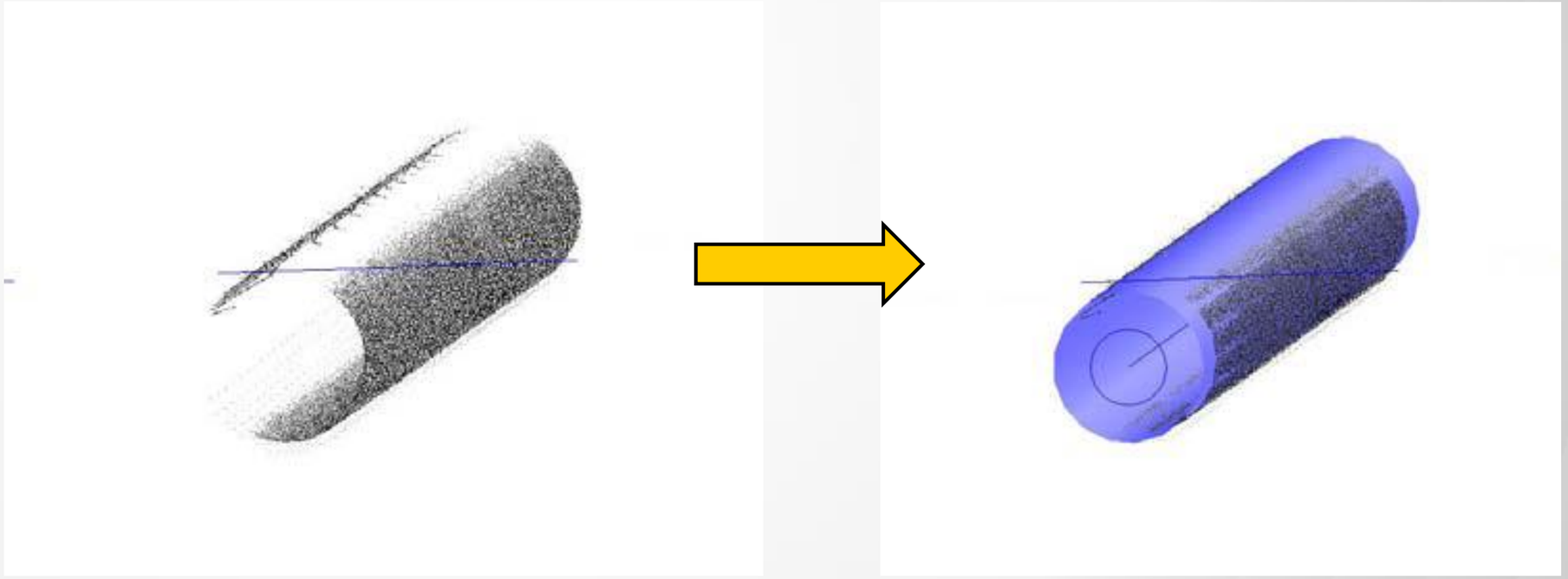
Summary

- Use service providers when required
  - F3 has more capabilities & more tools to chose from.
  - Know when to call in the experts.

Piping and Structural Extraction Process

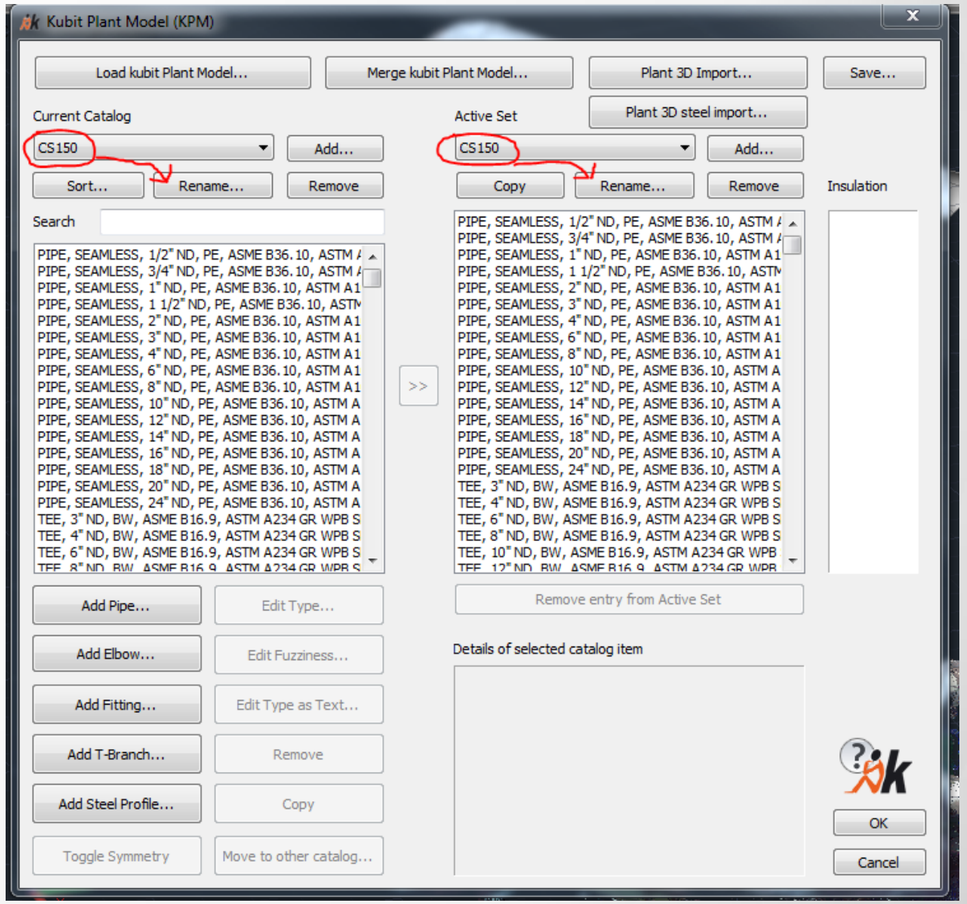
From Basic to Intelligent : Overview

- Find generic shapes in point cloud data
  - Cylinder
  - Torus
  - Cone



From Basic to Intelligent : Overview

- Match generic shapes with catalog-specific piping components
  - Cylinder = Pipe
  - Torus = Elbow
  - Cone = Reducer

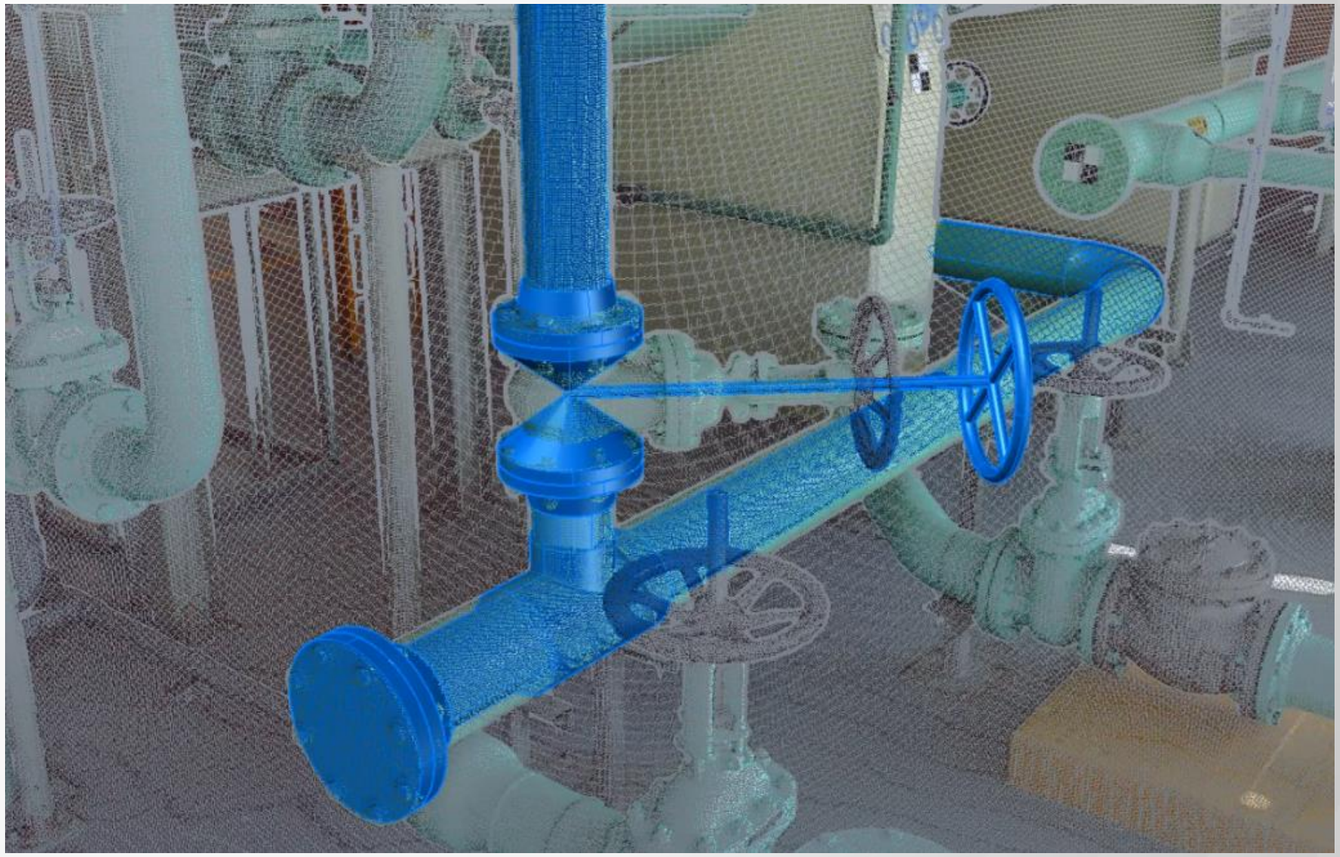


From Basic to Intelligent : Overview

- Verify connections and govern engineering limitations
  - Match flange ratings, schedules, specs, etc.
  - Eliminate options that can’t physically occur in the real world

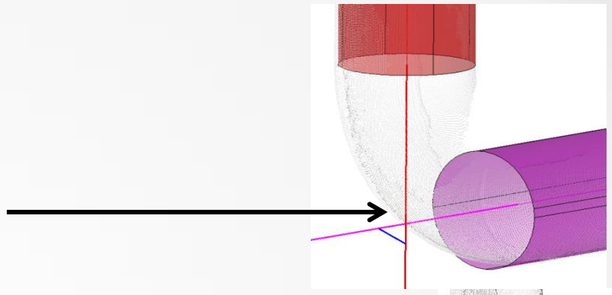
Semi-Automated Method for Pattern Recognition

- Focus on a specific pipe run or tie in
- Verify results in real-time with previews directly on the point cloud data
- No unintentional objects get modeled



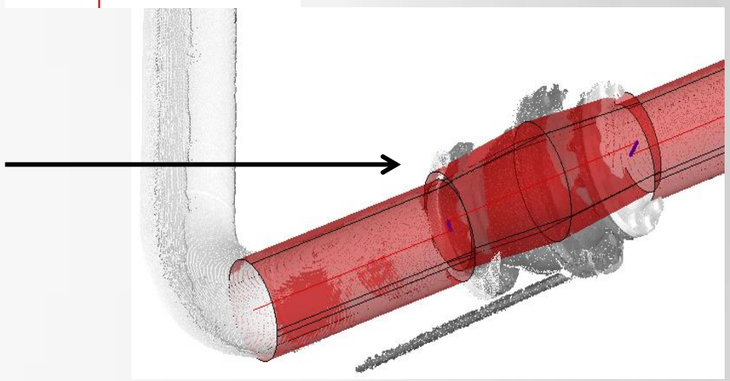
Moving Real World Data to Design World Constraints

Design Software is made for
Greenfield situations, not
Brownfield.



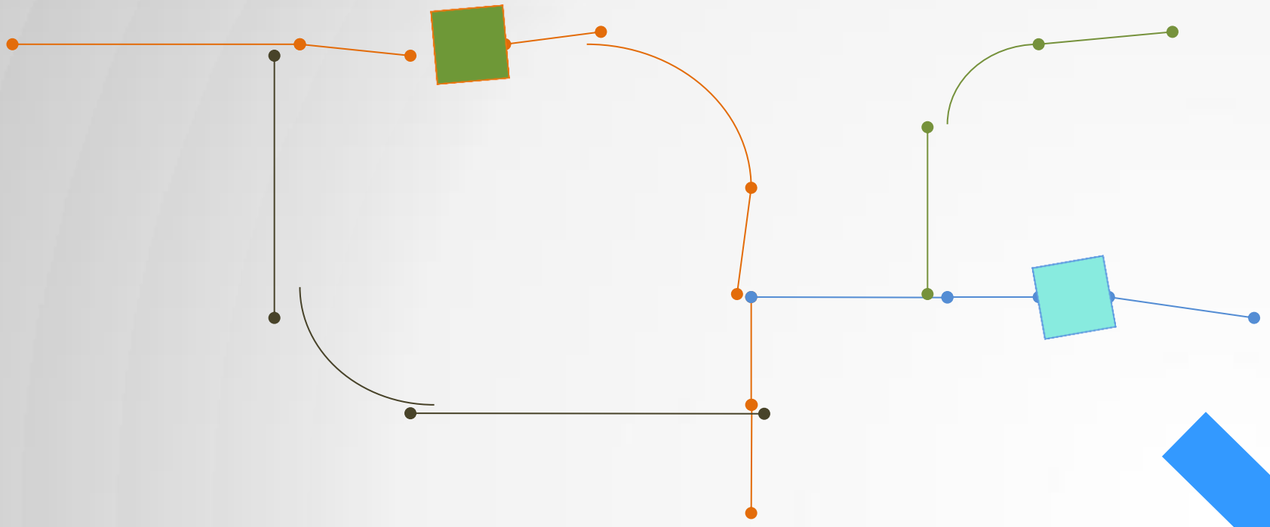
Such programs typically expect:

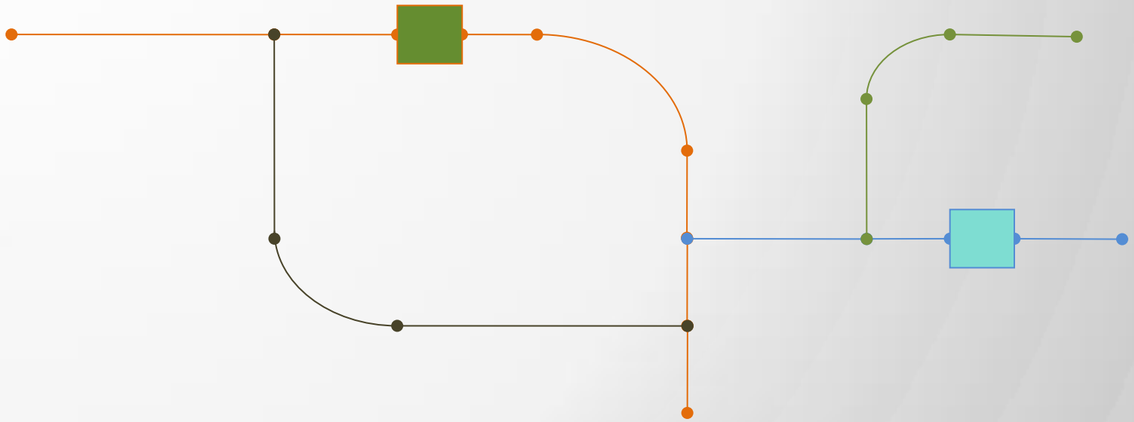
- Connected objects
- Coaxial / coplanar axis
- Perfect angles
- Standard objects



↳ Global Optimization is needed

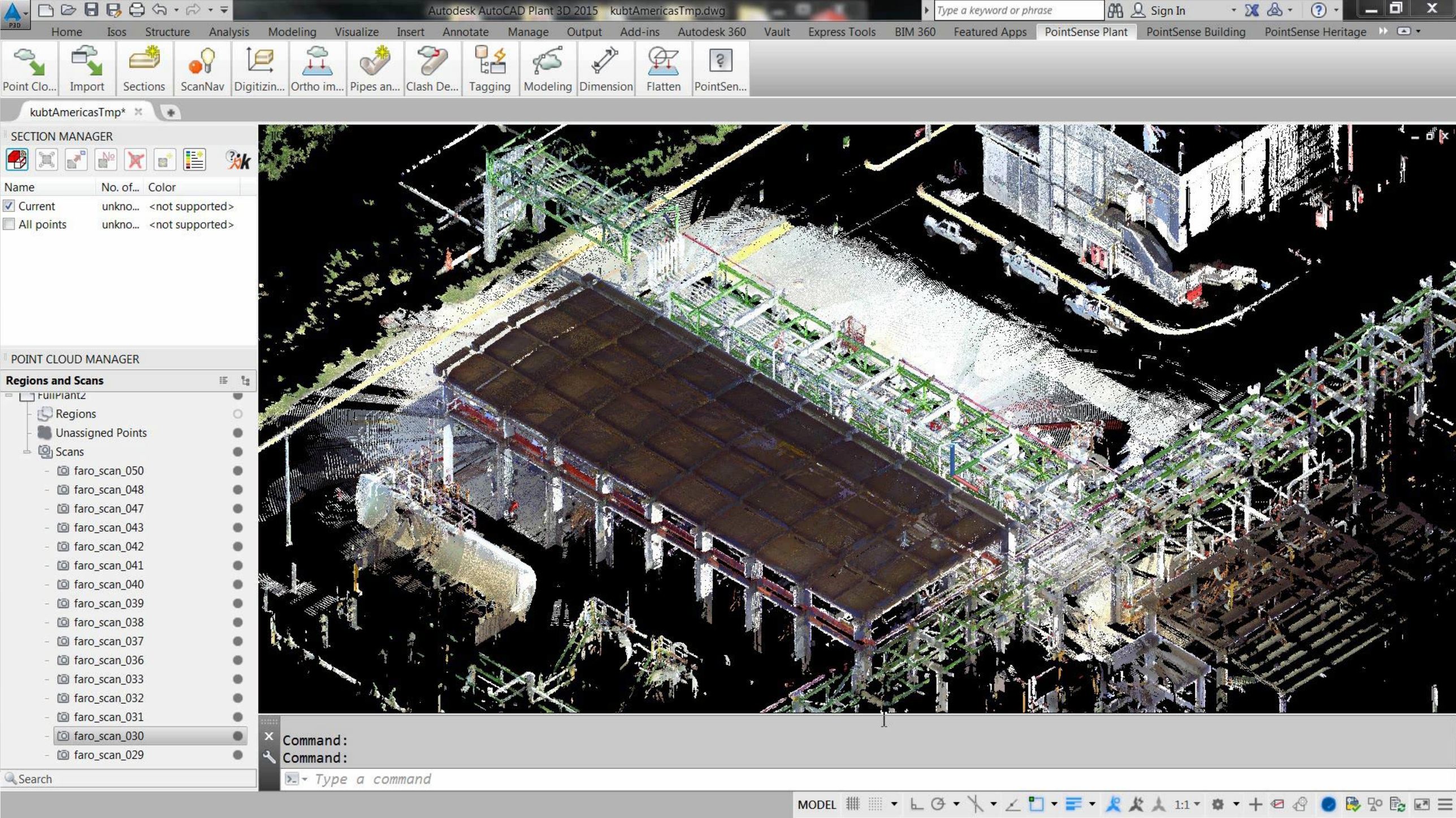
Moving Real World Data to Design World Constraints





Intelligent Design Objects and Deliverables

- Automatically create intelligent Plant3D objects
- Generate isometrics, bill of materials, orthographics, etc.
- Additional exports of intelligent centerlines available for other design tools


Autodesk AutoCAD Plant 3D 2015 kubtAmericasTmp.dwg
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Regions and Scans
FullPlant2
Regions
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Scans
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Command:
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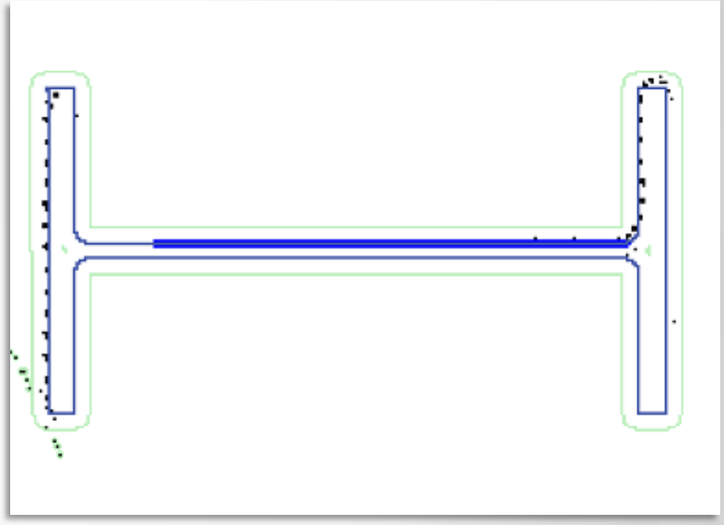
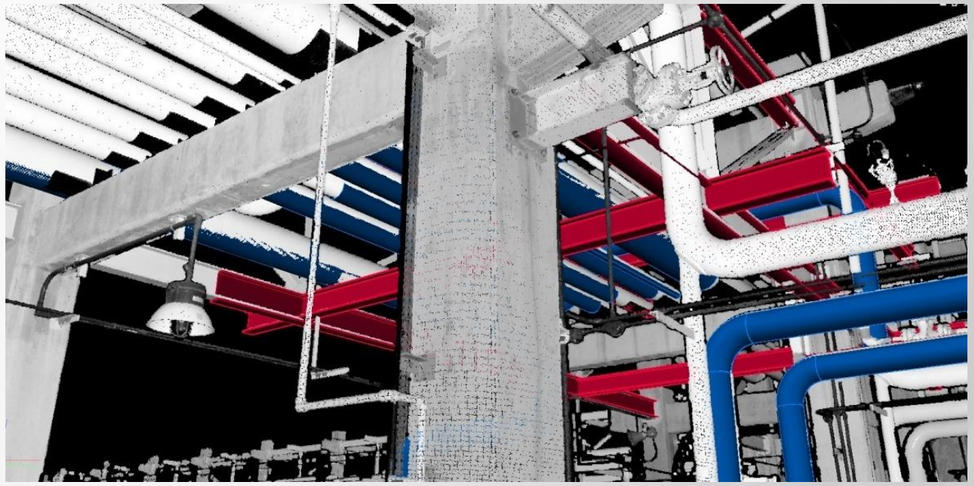
MODEL
1:1

Structural Recognition and Placement

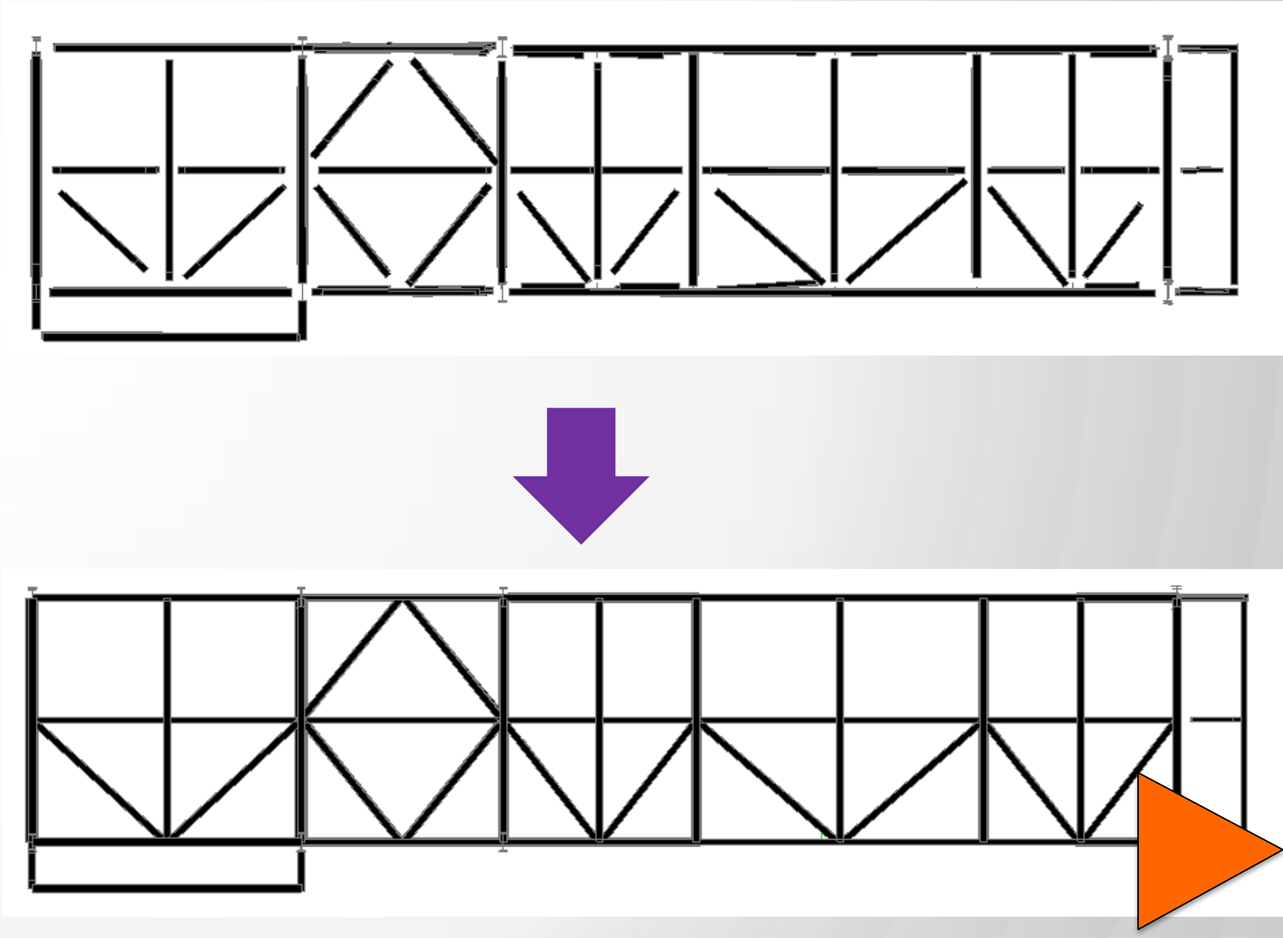
- Challenges
  - Structural profiles are typically incomplete in cloud data
  - Many different beam types look exactly the same from a specific vantage point
- Solutions
  - Automatic detection of correct patterns
  - Multiple filter options like beam-type, data cleaning, etc.
  - Real-time preview of structural results directly on the data

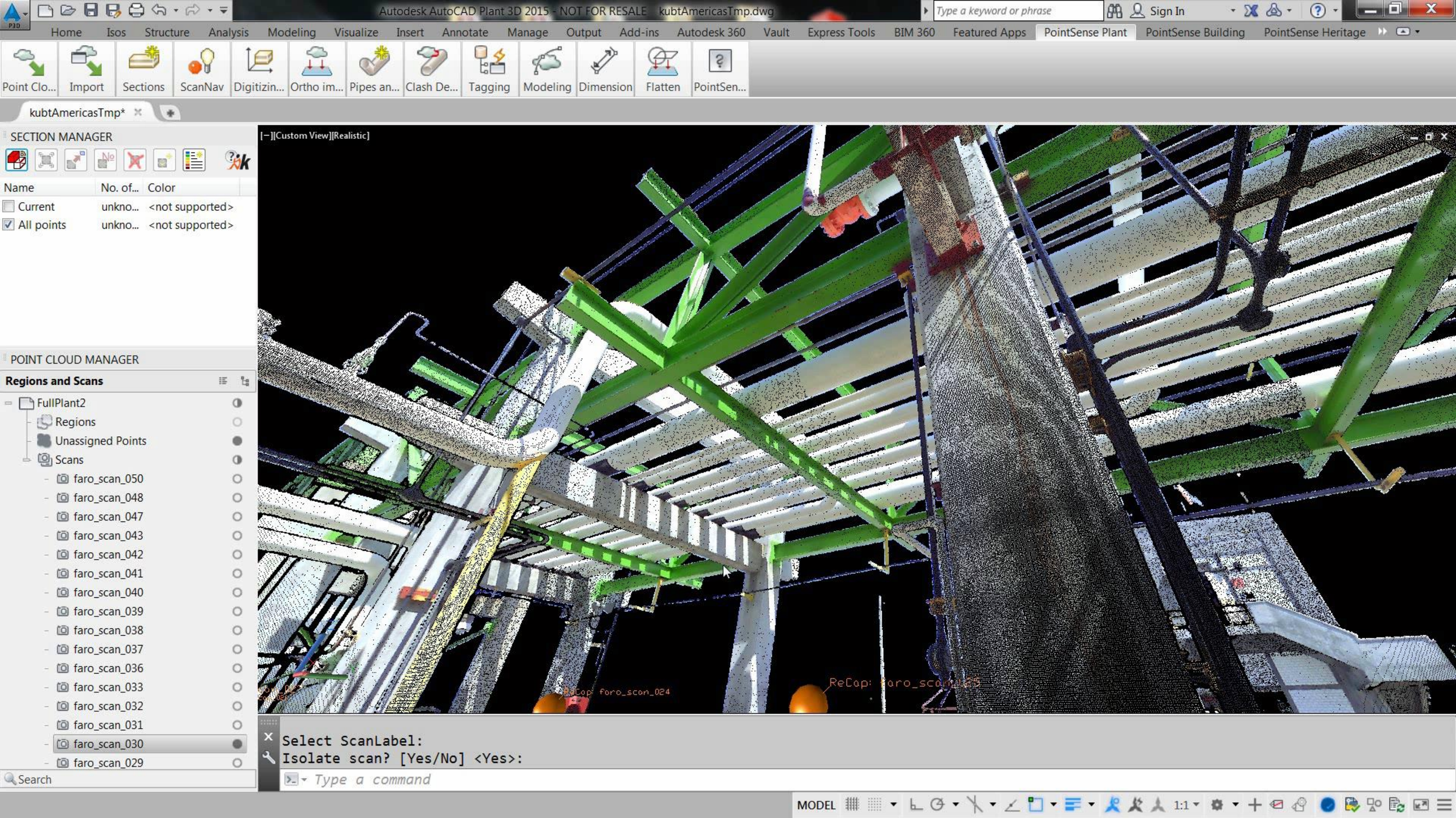




Creating Structural Grids and Exporting to Design

- Multiple options for post-editing (i.e. stretch, rotate, change profile, etc.)
- Find grids for vertical, horizontal, and diagonal beams
- Get results to structural design package to create final deliverables




Autodesk AutoCAD Plant 3D 2015 - NOT FOR RESALE kubtAmericasTmp.dwg
Type a keyword or phrase
Sign In
Home Isos Structure Analysis Modeling Visualize Insert Annotate Manage Output Add-ins Autodesk 360 Vault Express Tools BIM 360 Featured Apps PointSense Plant PointSense Building PointSense Heritage
Point Clo... Import Sections ScanNav Digitizin... Ortho im... Pipes an... Clash De... Tagging Modeling Dimension Flatten PointSen...
kubtAmericasTmp*
SECTION MANAGER
Name No. of... Color
Current unkno... <not supported>
All points unkno... <not supported>
POINT CLOUD MANAGER
Regions and Scans
FullPlant2
Regions
Unassigned Points
Scans
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faro_scan_048
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faro_scan_042
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faro_scan_037
faro_scan_036
faro_scan_033
faro_scan_032
faro_scan_031
faro_scan_030
faro_scan_029
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ReCap: faro_scan_024
Select ScanLabel:
Isolate scan? [Yes/No] <Yes>:
Type a command
MODEL
1:1

User Experience: Reducing Turnaround Time with Reality Computing

Background & Bio:

Eric Kirsch, Piping Design Supervisor

- Jacobs Engineering (Costa Mesa, CA)
- Previous: Piping Design Supervisor,
  - Marmac Field Services (24 years)
  - AutoCAD (25 years)
  - Navisworks
  - CADWorx, Plant 3D

Laser Scanning Experience:

- 2008: Exposed to laser scanning
  - 3rd party firm scanned and created 3D models
  - Competition began offering scan services directly
  - Limited modeling and tie-ins rather than full model
- 2010: Investigated software solutions
  - Began using AutoCAD 2010 with kubit PointSense Plant
  - Creating as-built models, tie-ins, structural to CADWorx
- 2012: Company purchased scanner
  - Completely independent workflow
  - Reduced overhead costs

Workflow Changes

- Bottlenecks
  - Older AutoCAD versions; limited point cloud capabilities
  - Limited PointSense knowledge/users
  - Limited Storage space; multiple scan formats
- Recent Upgrades
  - AutoCAD 2015 (Plant 3D) ease of use for new scan users
  - Improved visual quality and management of data

ISLAND CHAFFEE BOOSTER PUMPS

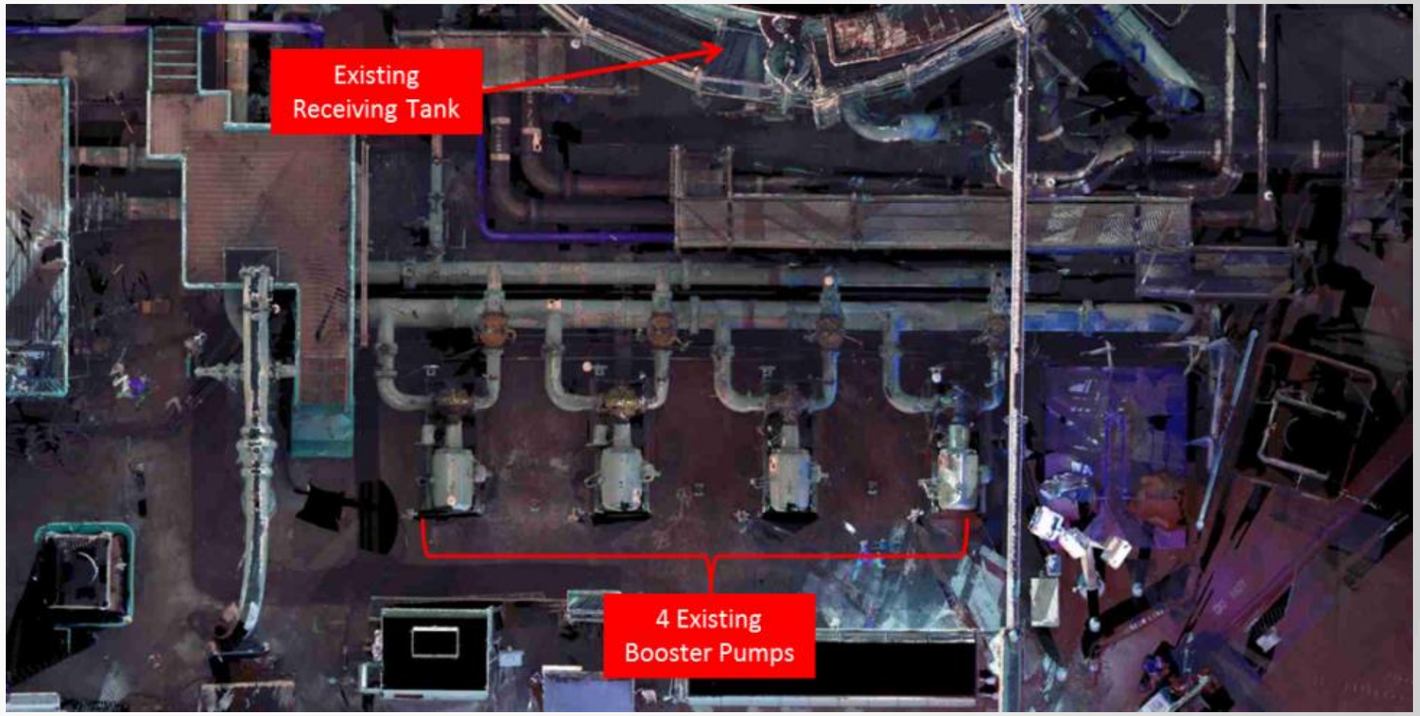
Demonstrate the work flow for locating existing tie-ins for the replacement of suction and discharge piping

Scope

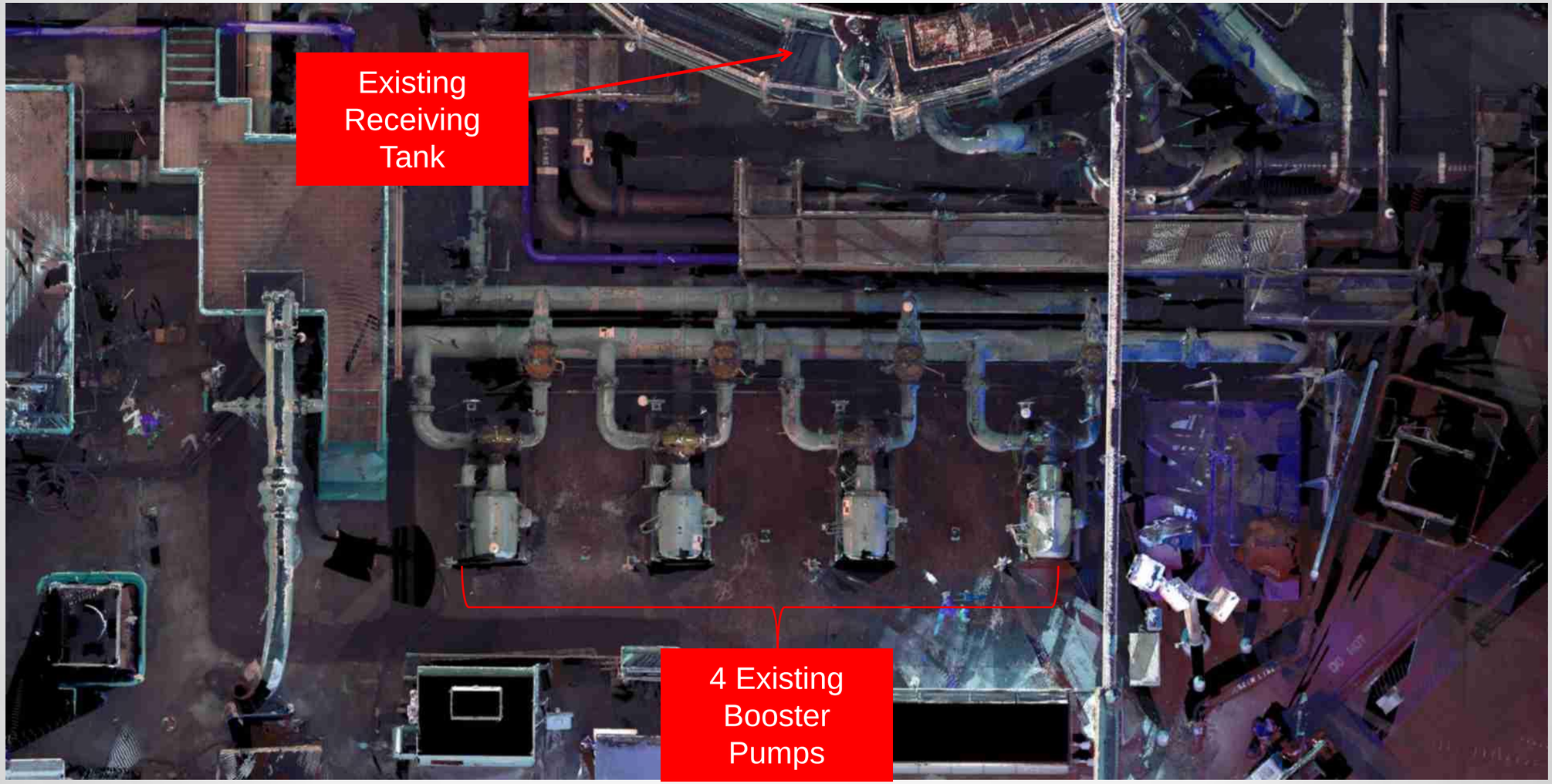
- More water volume required from existing tank
- Replace existing suction & discharge piping to/from existing pumps
- Install new 30” nozzle on existing tank
- Pre-fabricate design in shop
- Install within 24 hour shut-in time

Action Plan (capture)

- Scan Area
  - Faro Focus 3D
  - 22 scans, 2 man crew, one day
  - Survey crew to attach real world coordinates, one day



Original 22 Scans

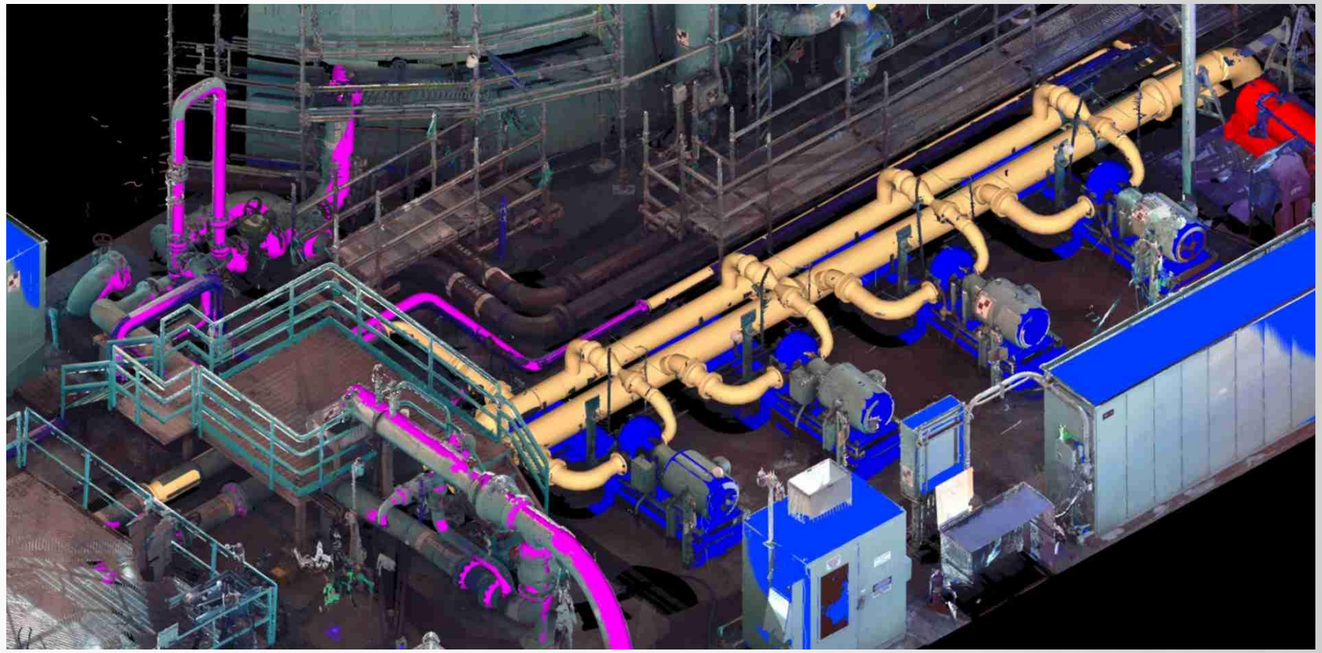


Action Plan (prepare)

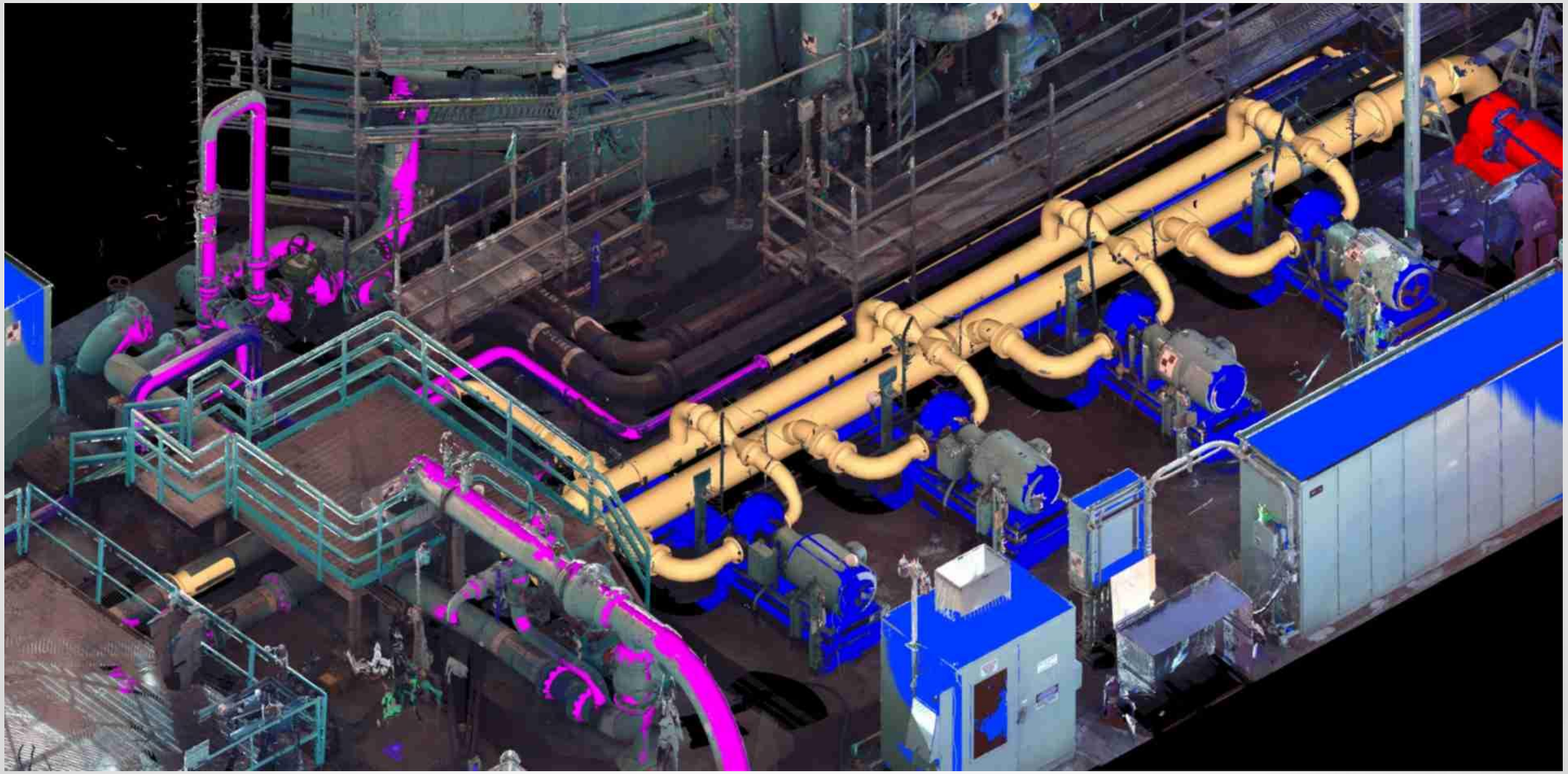
- Register scan data (Faro Scene)
- Index Faro files to AutoCAD 2013 (PCG format)
- Import Faro files to kubit VirtuSurv

Action Plan (create)

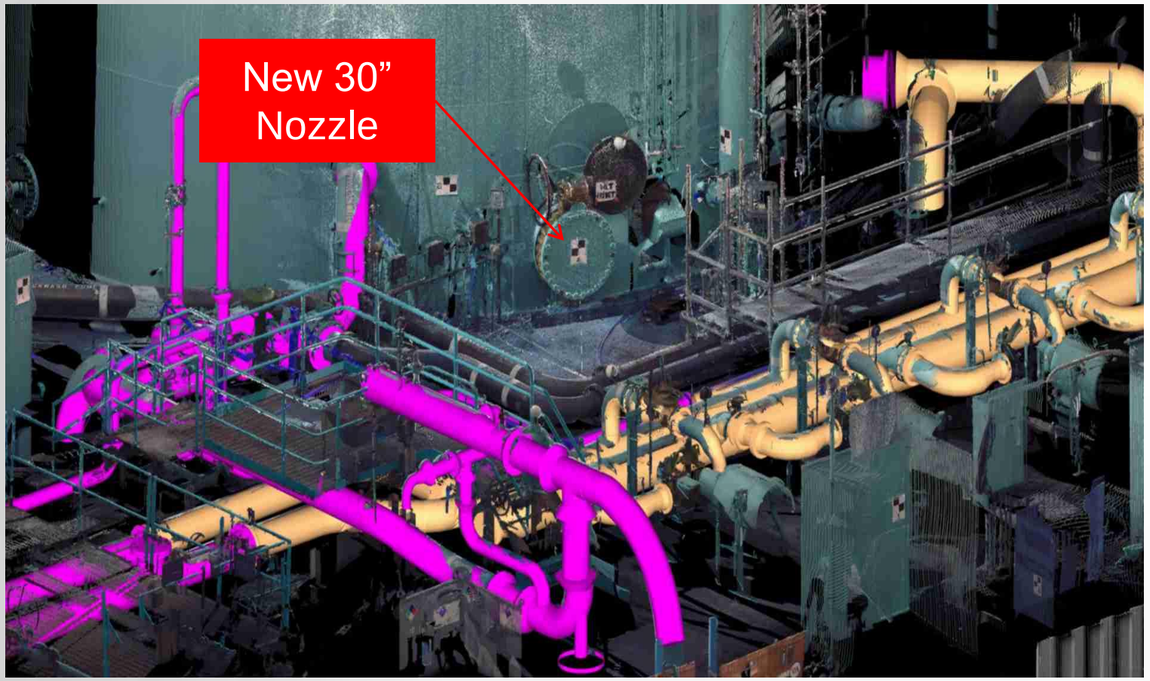
- Begin identifying tie-in points and interferences
- Using PointSense Plant



Modeling Tie-ins and interferences

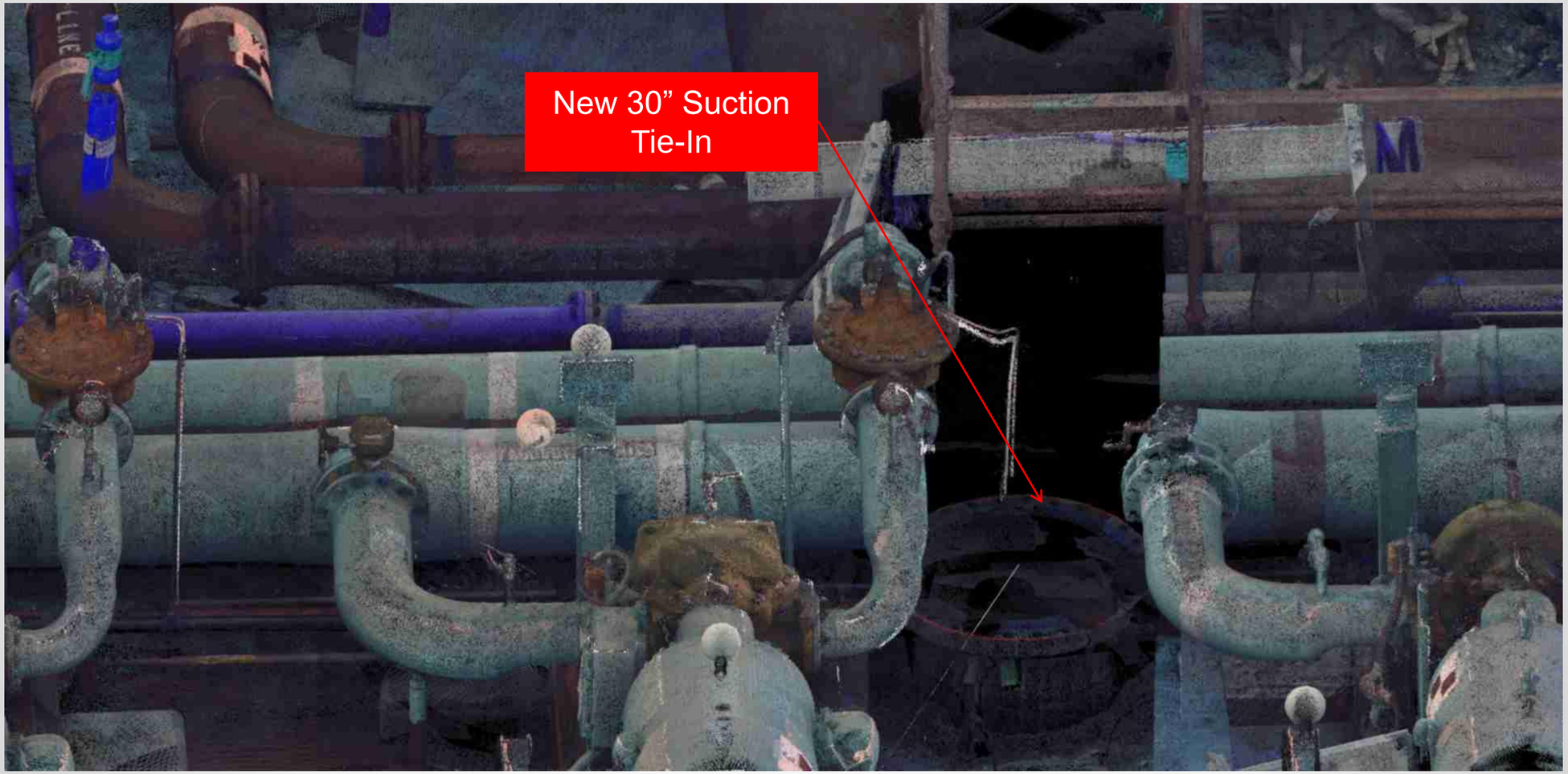


New 30” Nozzle

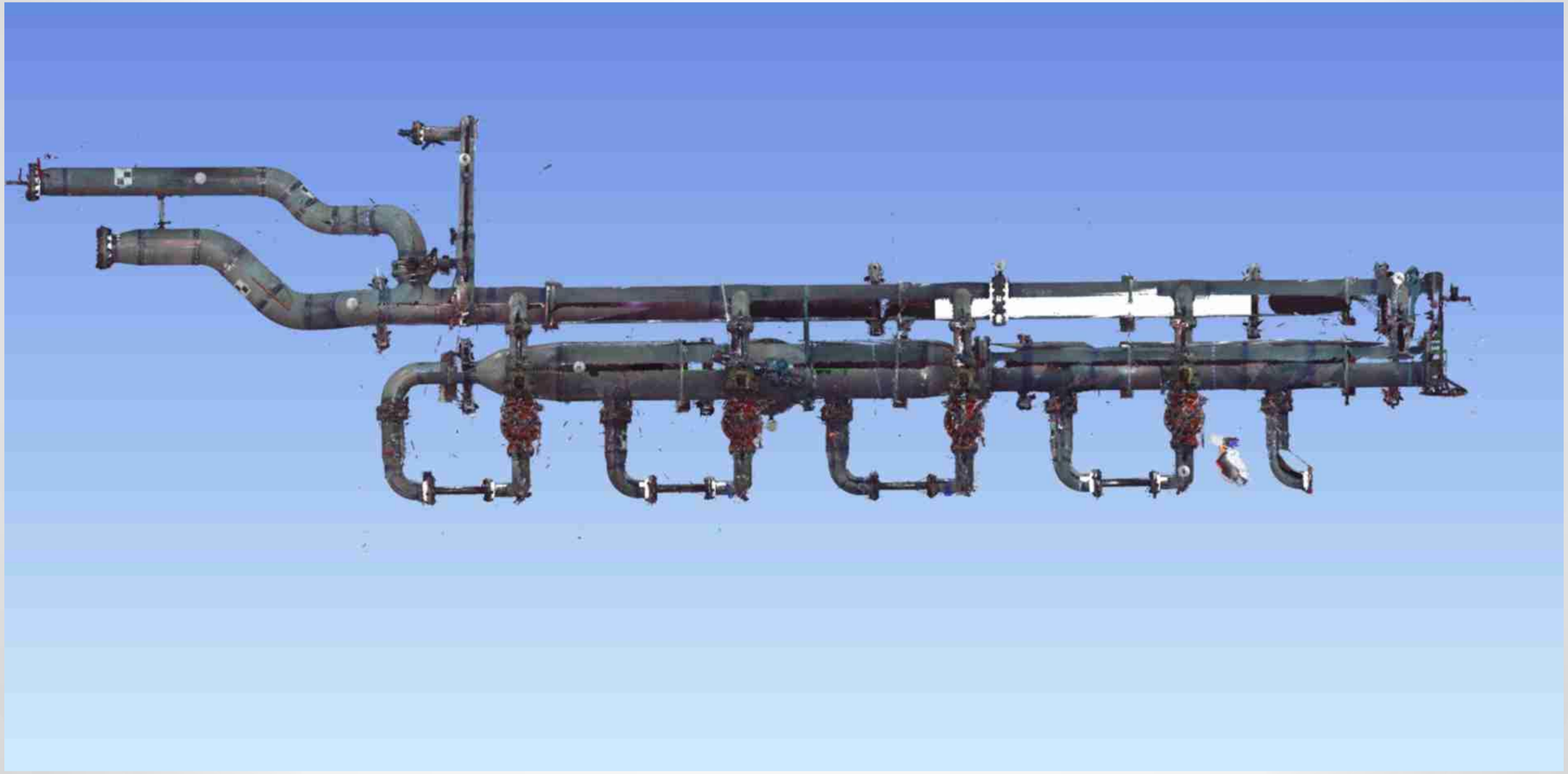


New 30” Suction Piping

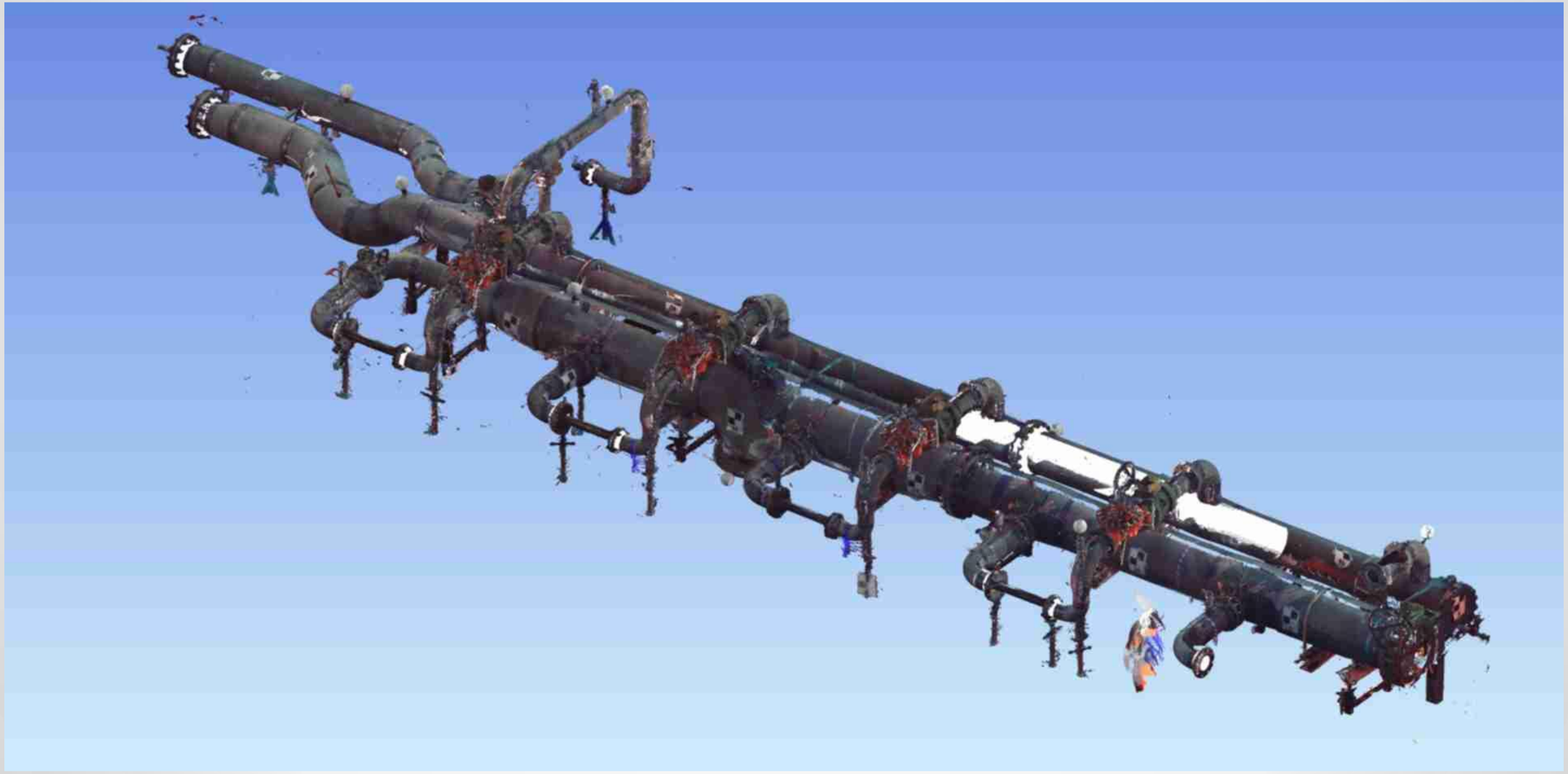
New 30” Suction Piping



Mock Up

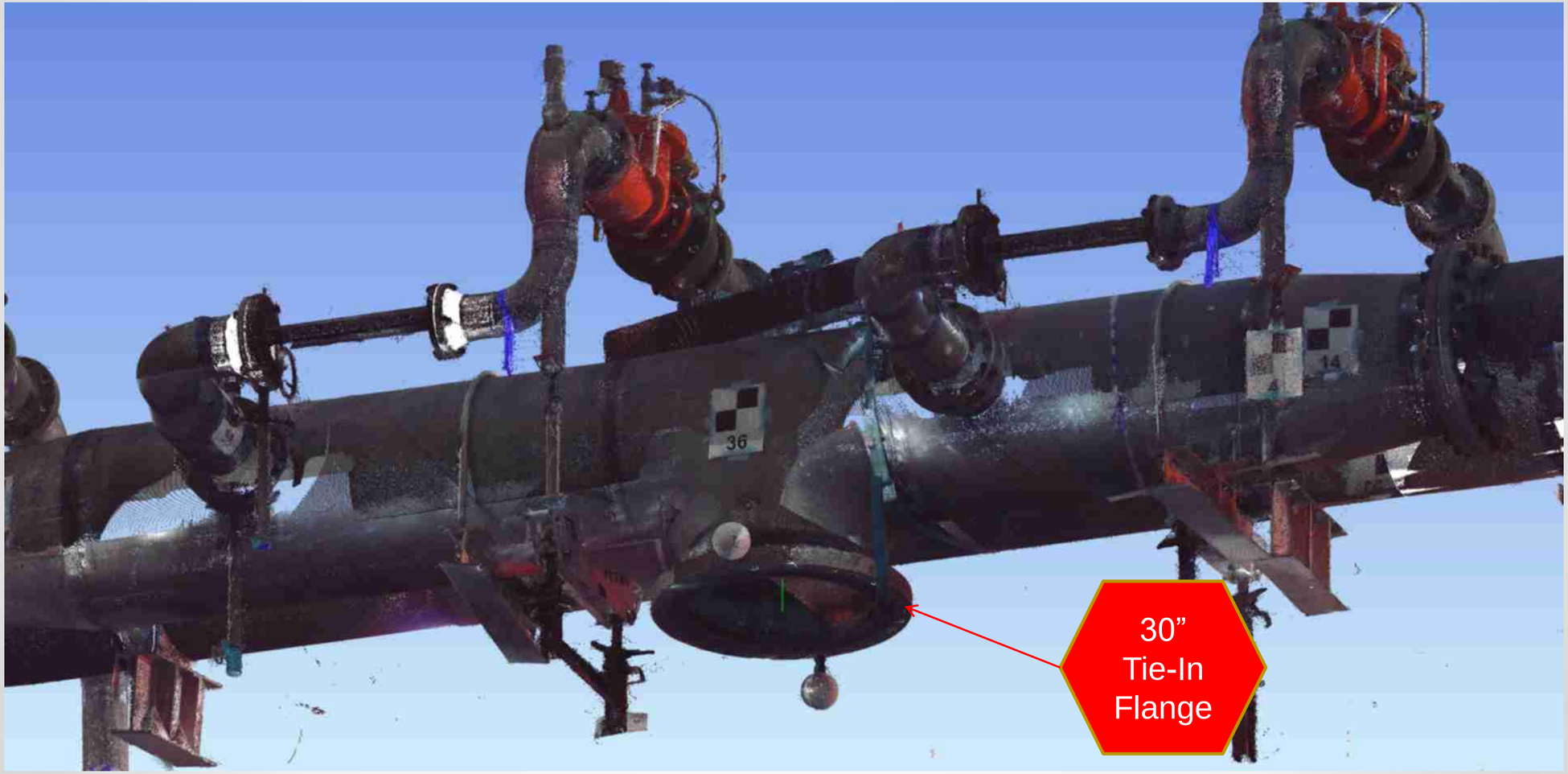


Mock Up

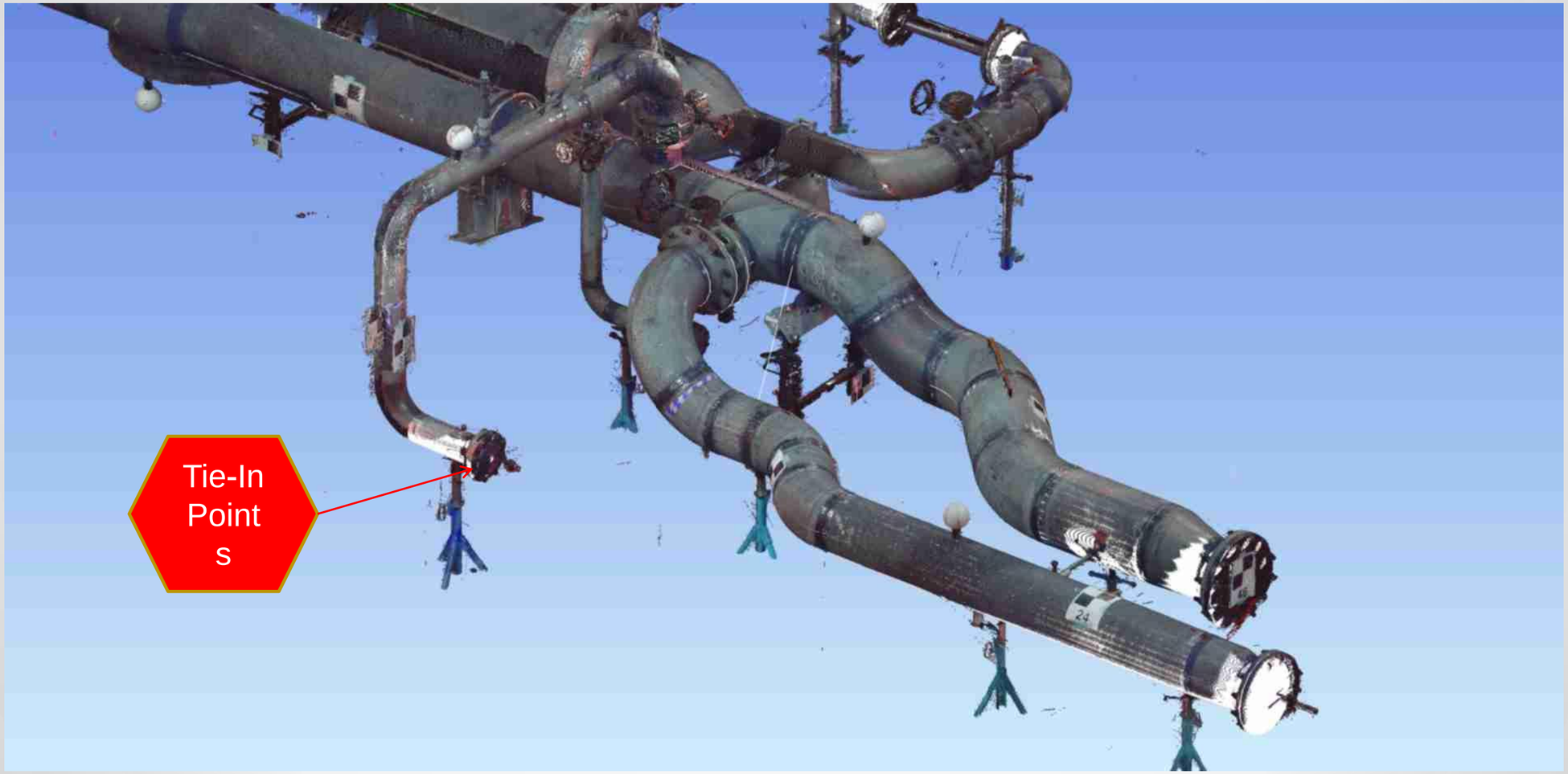


Mock Up

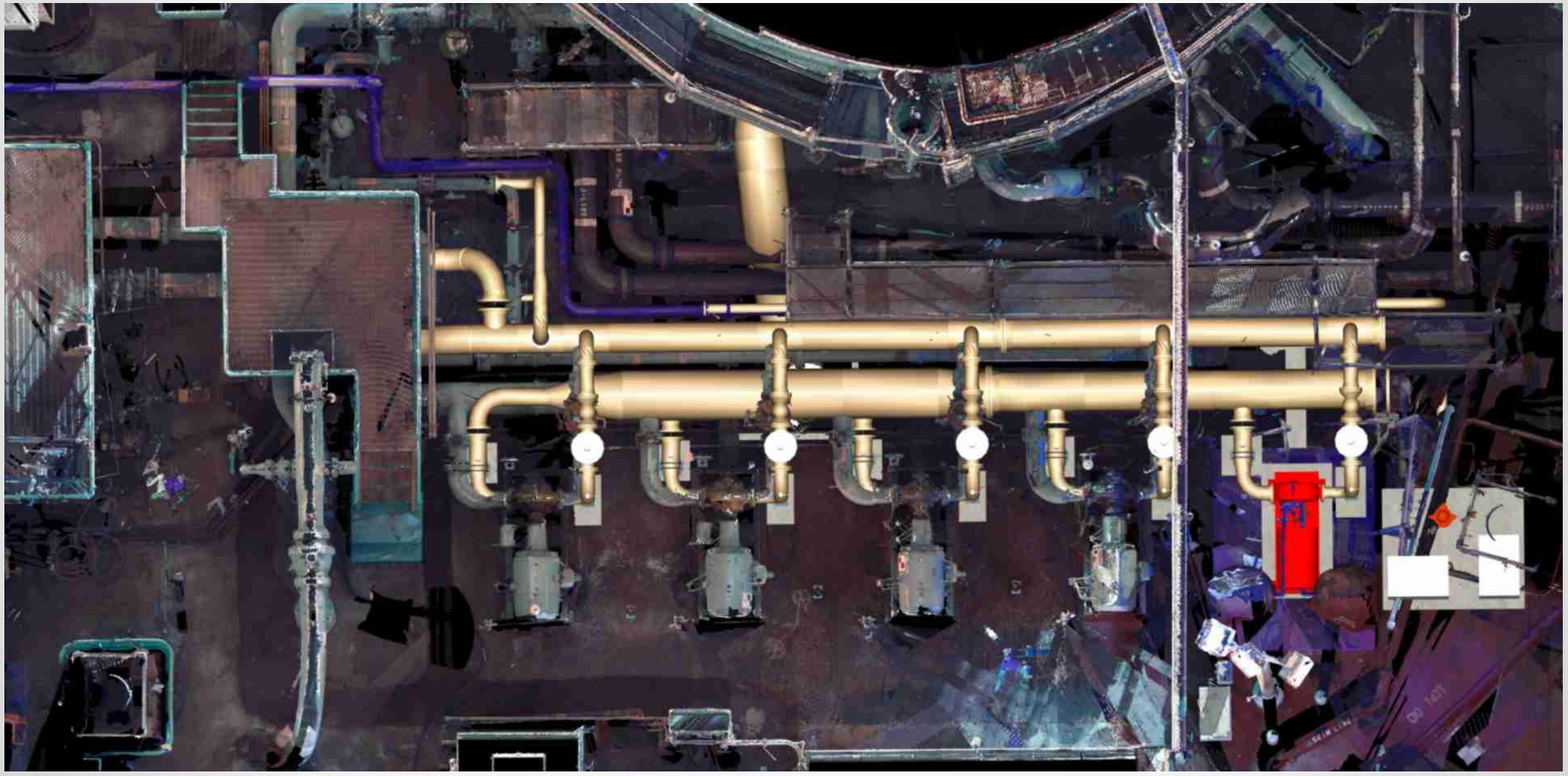
Mock Up



Mock Up

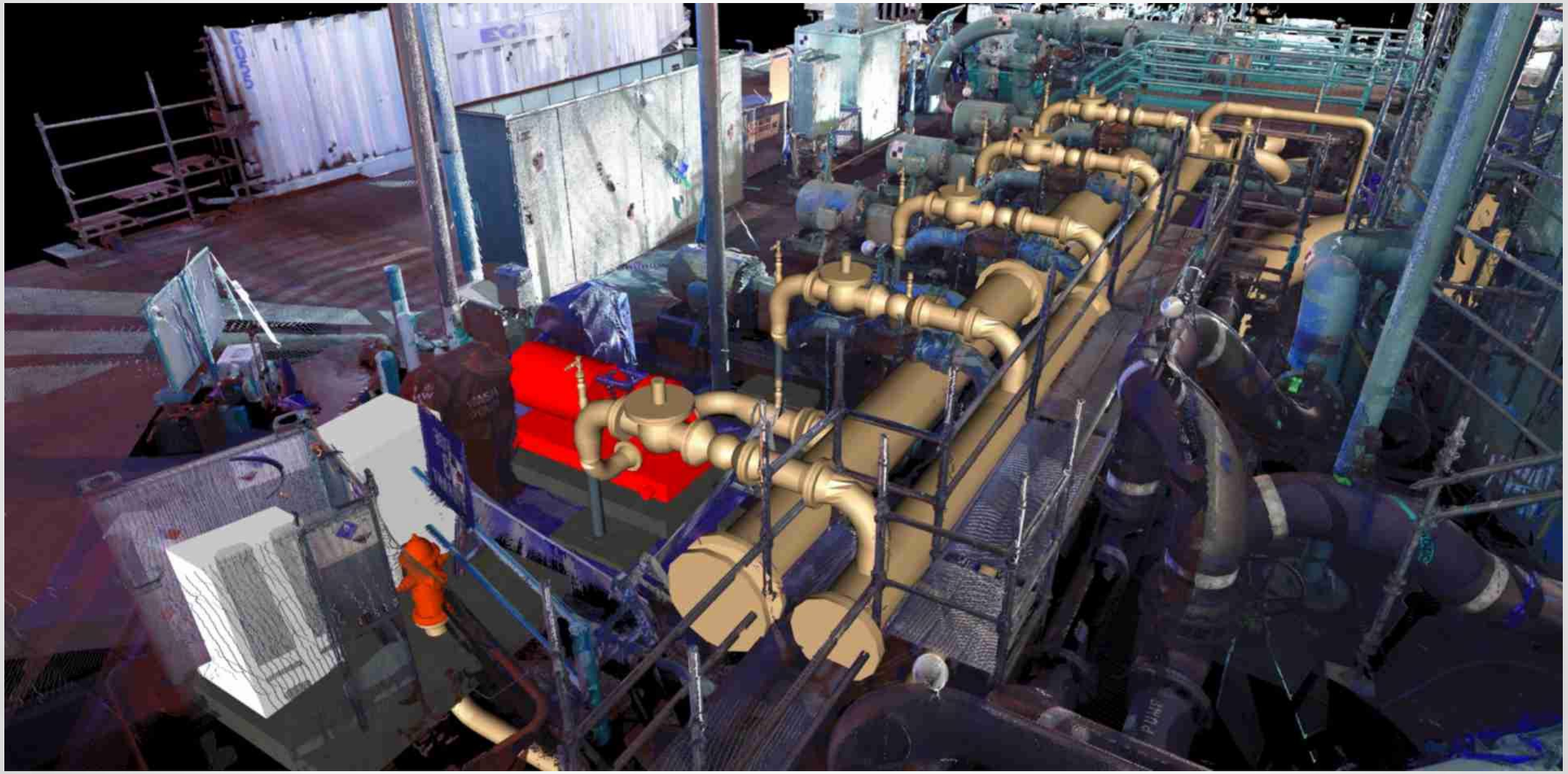


As-Built



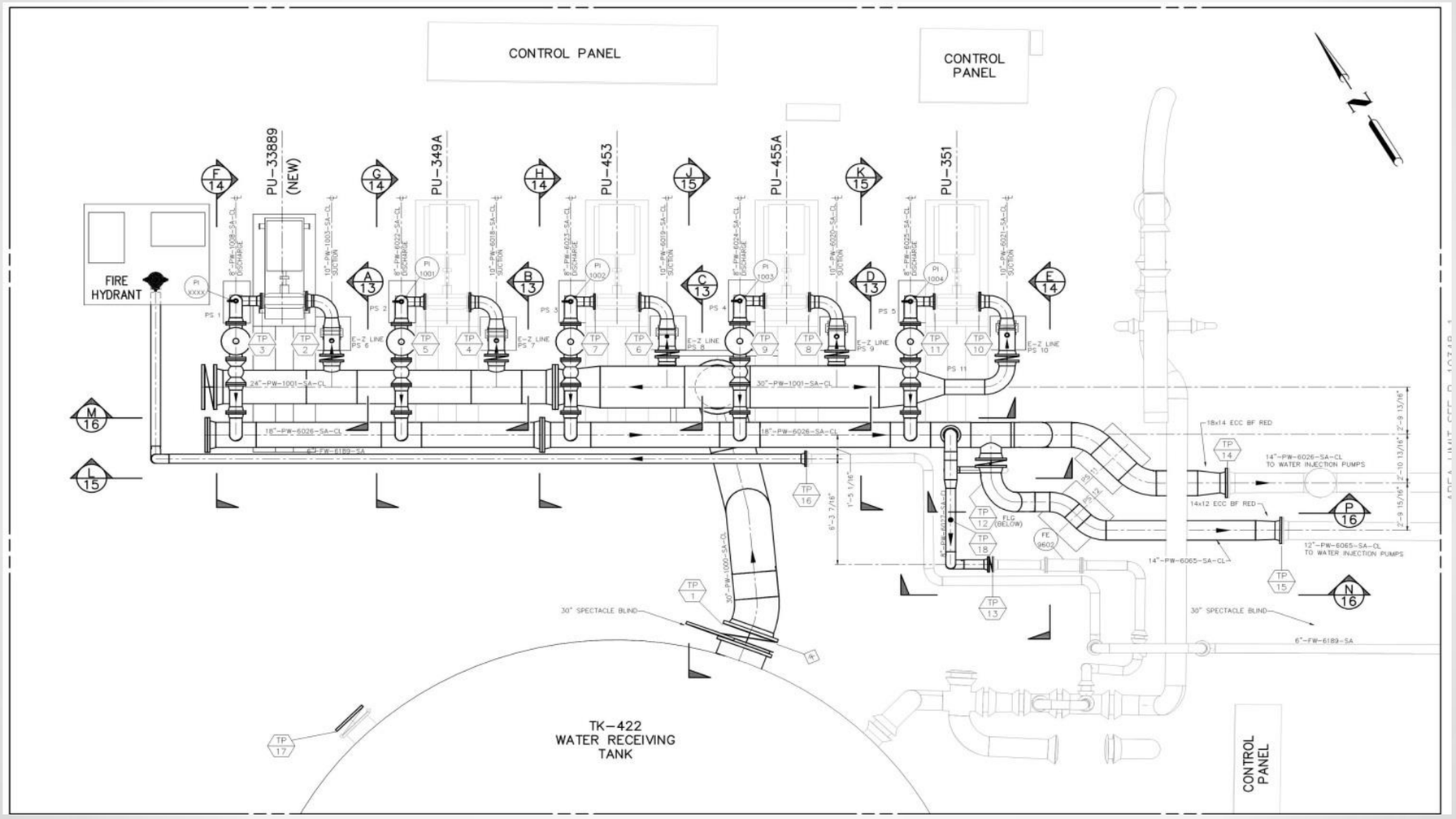
As-Built

As-Built

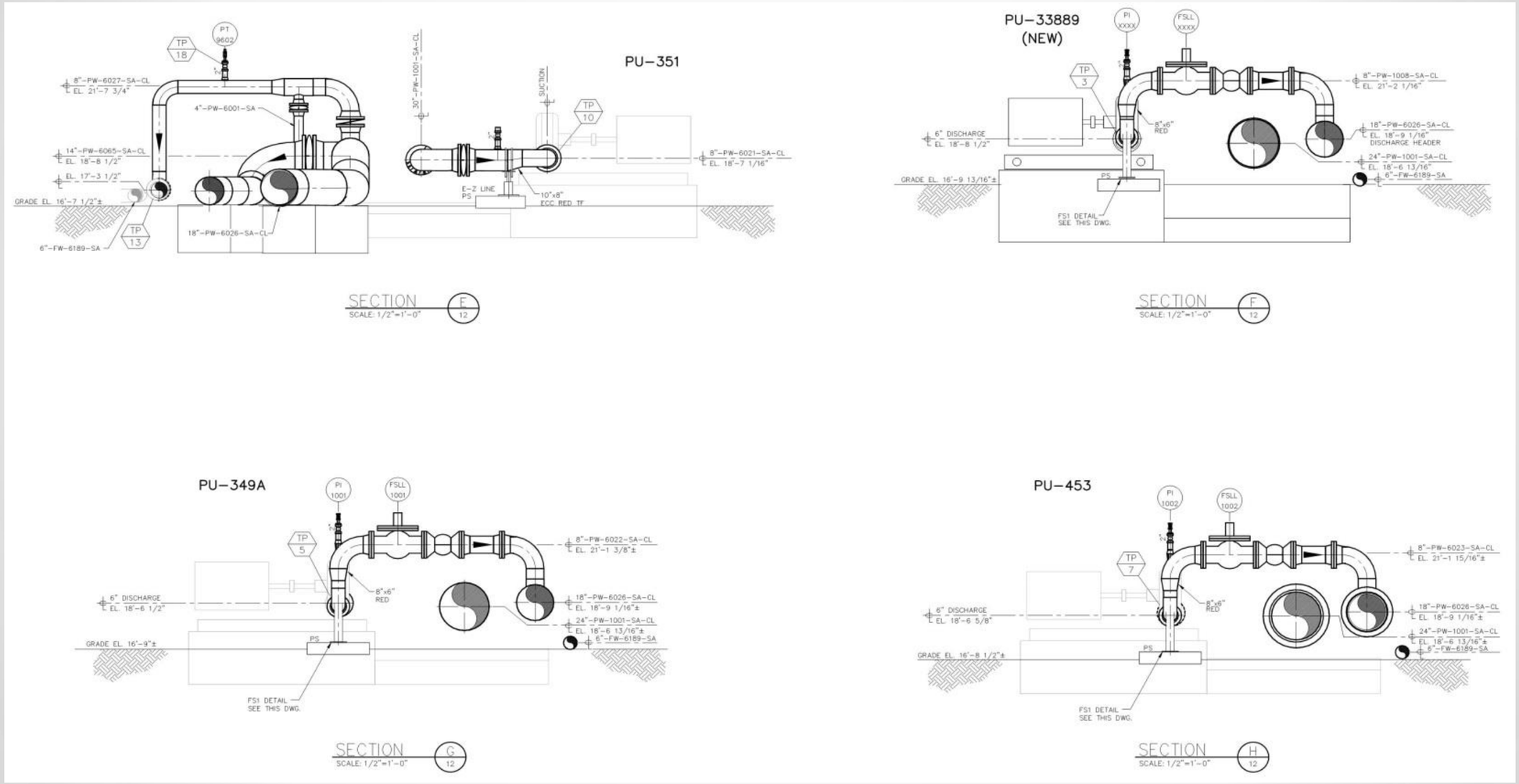


As-Built

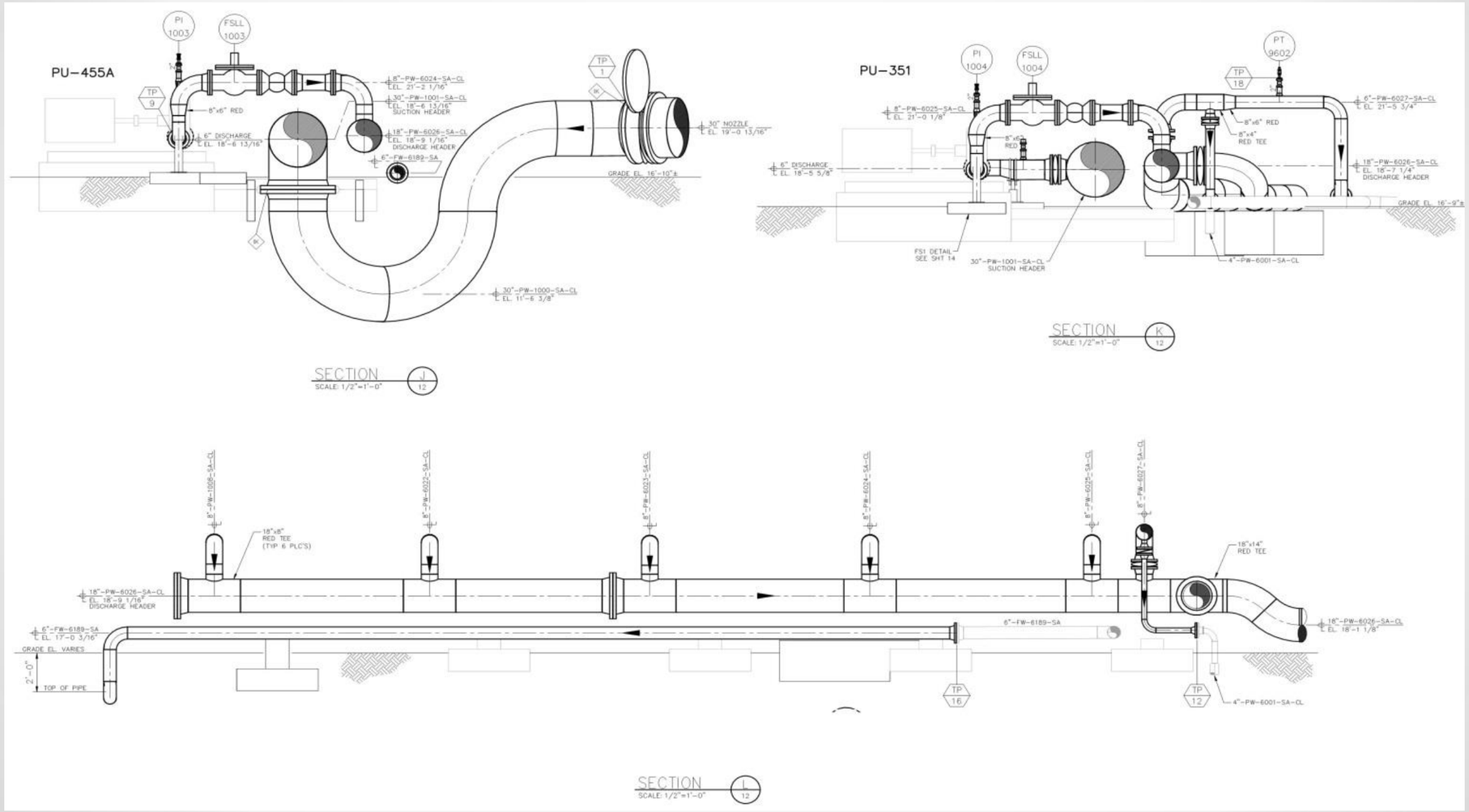
Deliverables



Deliverables



Deliverables



Construction/Success

Construction/Success

Construction/Success

Challenges

- Unexpected revisions /add-ons
- Integrating multiple new scans
- Tight scheduling requirements

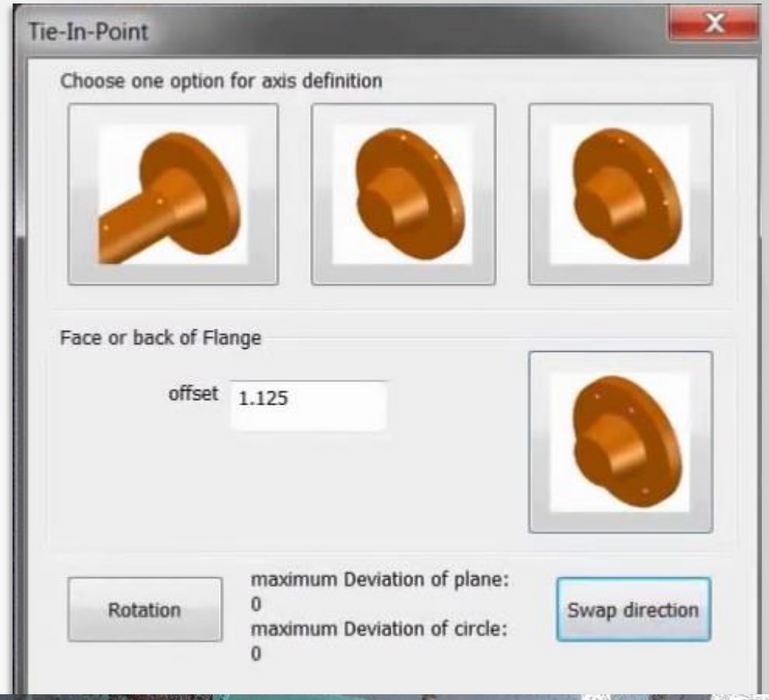
Project Summary

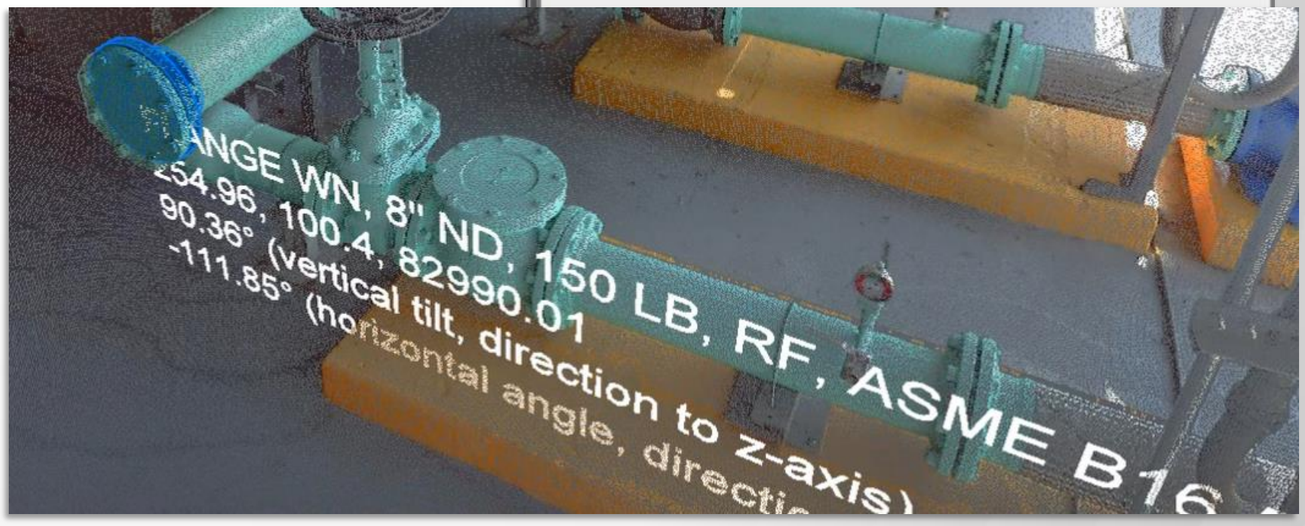
- Completion 10 hours ahead of schedule
- The project has eliminated pump cavitation
- Approx. $500,000 saved in just production

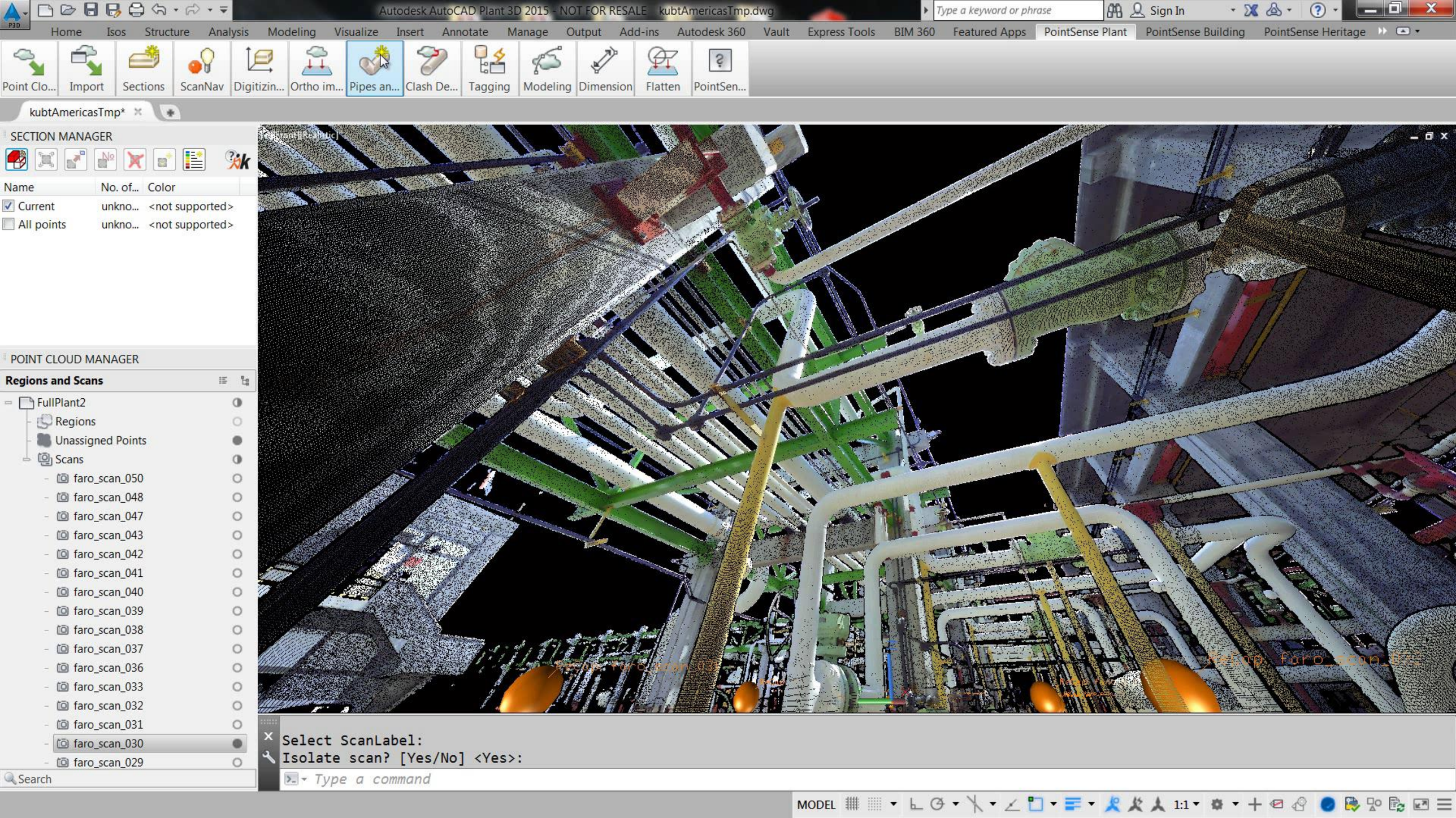
Extracting tie-in points and performing clash detection

Why Tie In Points?

- Point clouds are dense enough to provide the majority of background information
- Why model anything you don’t have to?
- Just need a single connection point to attach new/existing design



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Regions and Scans
FullPlant2
Regions
Unassigned Points
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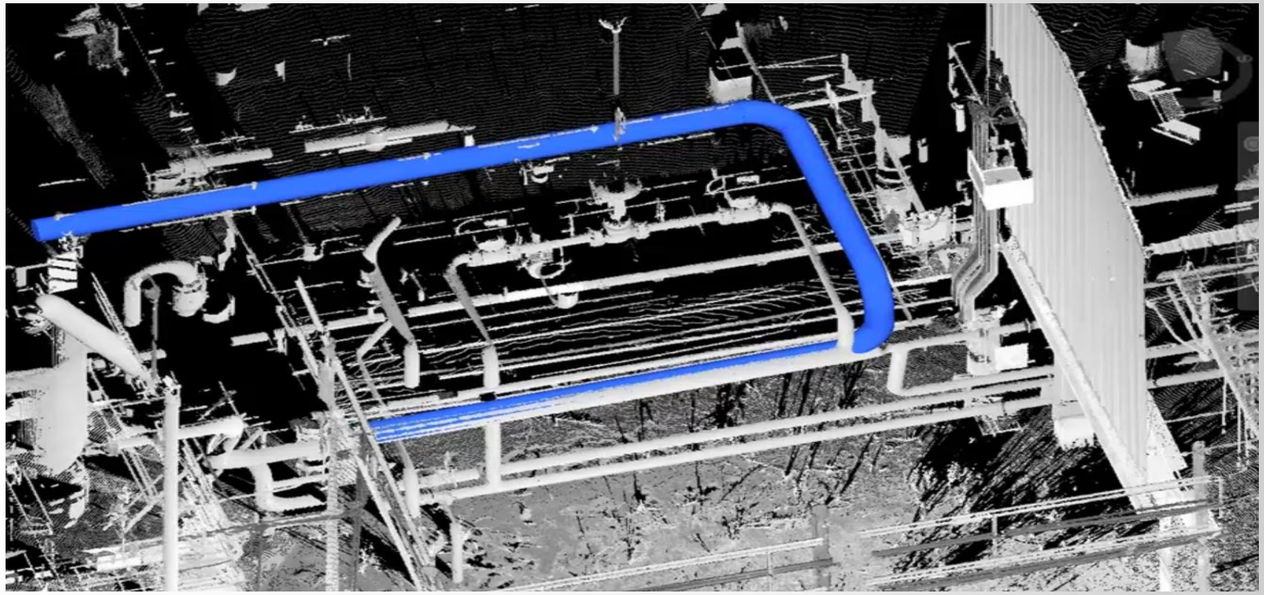
Clash Detection

- Detect issues between existing conditions and proposed design
- Easy Navisworks workflow
  - Insert modeling and RCP file from ReCap
  - Use Clash Detective tool with or without tolerance
  - View all clashes and generate reports

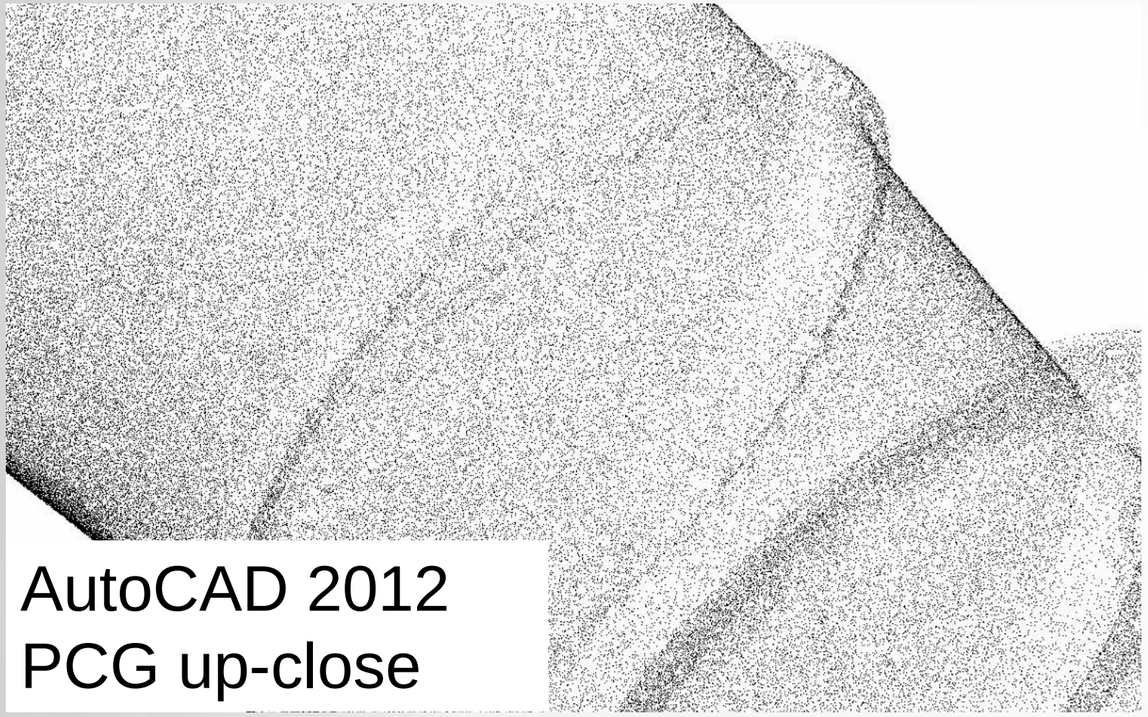


User Experience:
Equipment Analysis
(Tank Volume and Deformation)

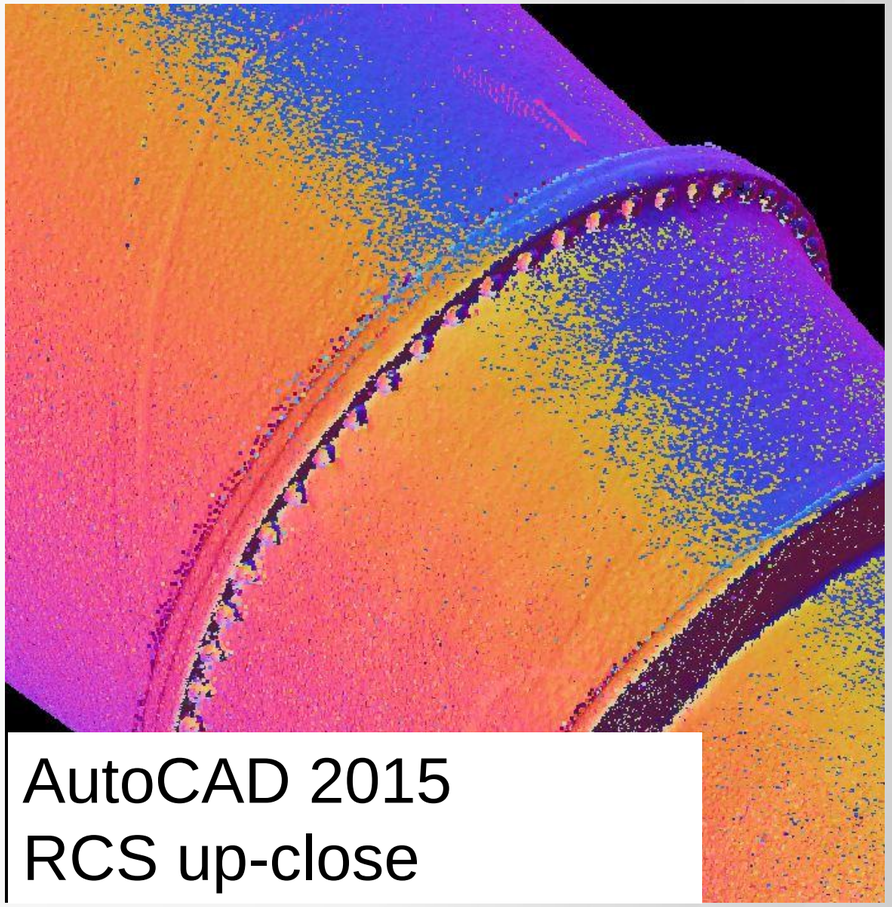
Aaron Hunt, Technical Manager

- Laser Scanning and BIM service provider
  - Toledo Ohio
- 20+ years AutoCAD experience
- Began using AutoCAD point clouds in 2012

Then and Now



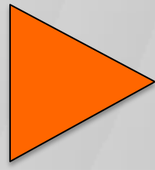
AutoCAD 2012
PCG up-close



AutoCAD 2015
RCS up-close

TANK DOCUMENTATION

Evaluating tank volumes
and deformation in AutoCAD

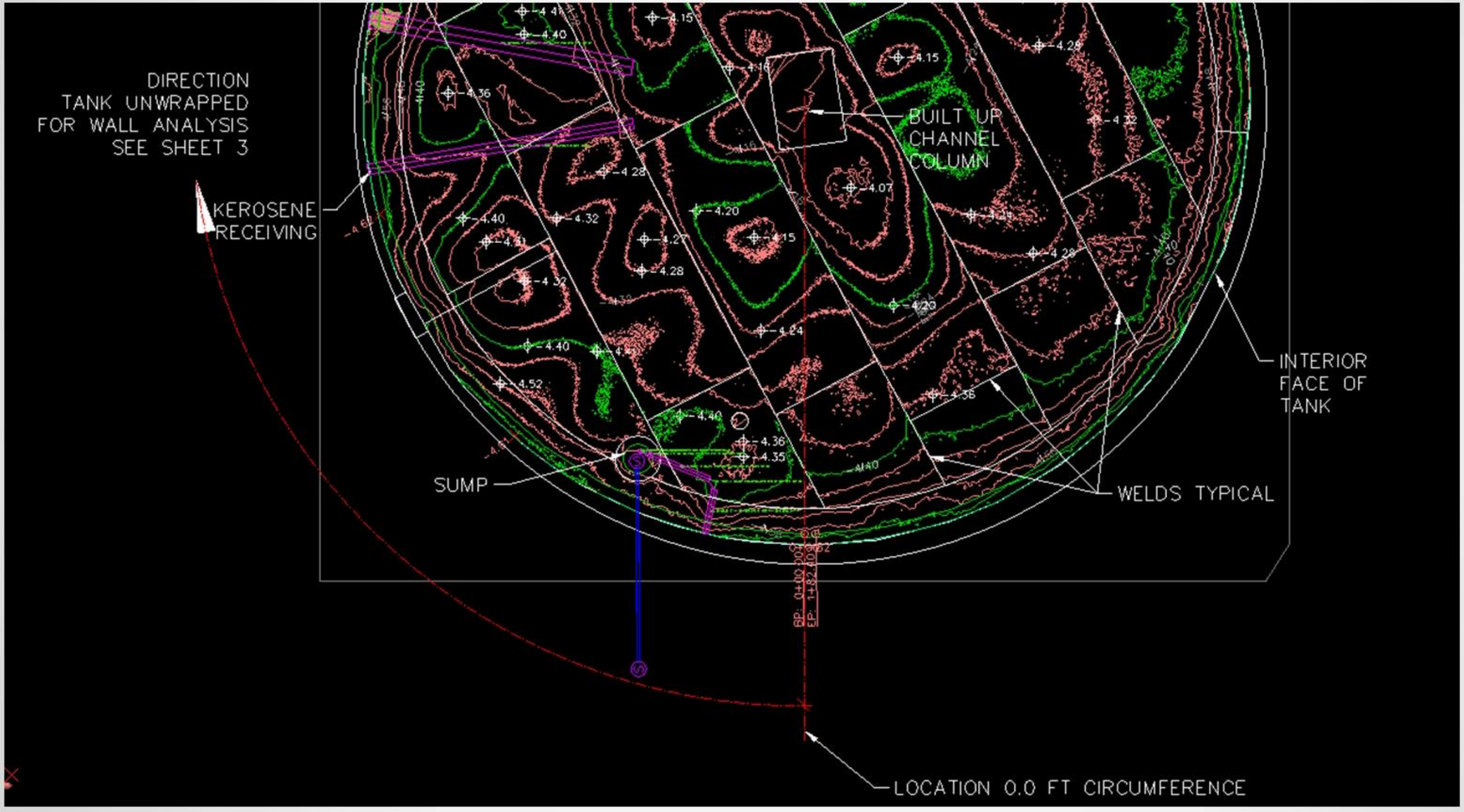


User Experience:
Equipment analysis
(Tank Volume and Deformation)

Action Plan

- Collected Scan data
  - Registered data (Cyclone)
  - Isolated tank interior (3 scans)
- Imported PTS scan to Autodesk ReCap
  - Converted to RCS format for AutoCAD
  - Insert point cloud in AutoCAD Civil 3D
- Perform tank analysis
  - Using PointSense Plant

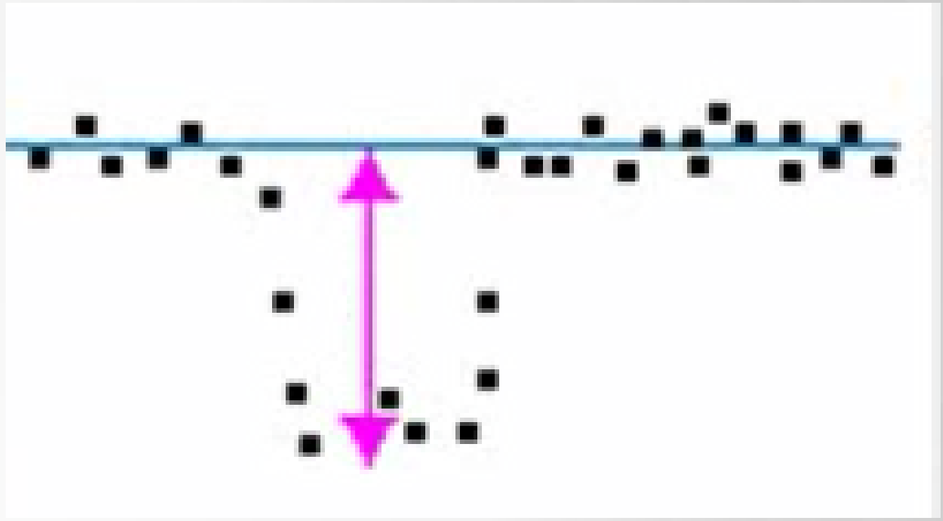
Location of Cylinder cut

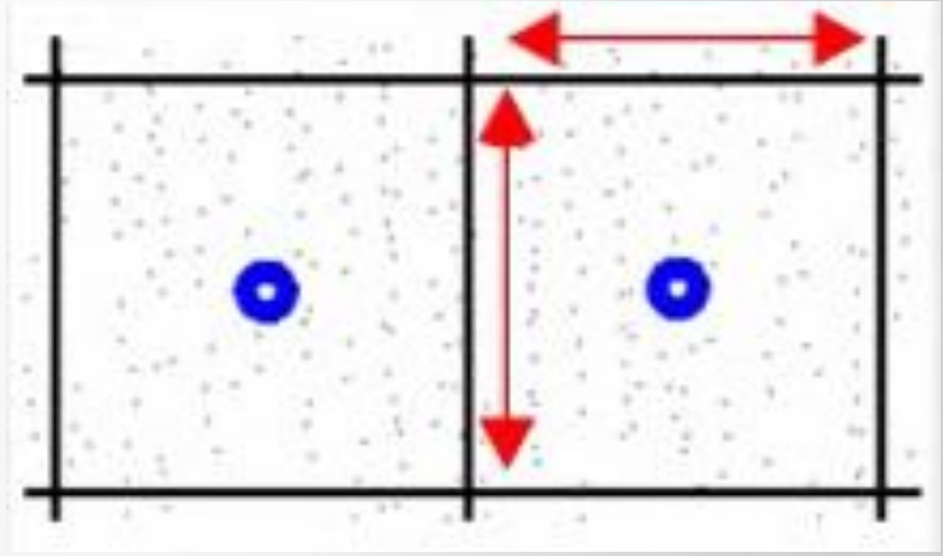


Deformation and volumetric analysis

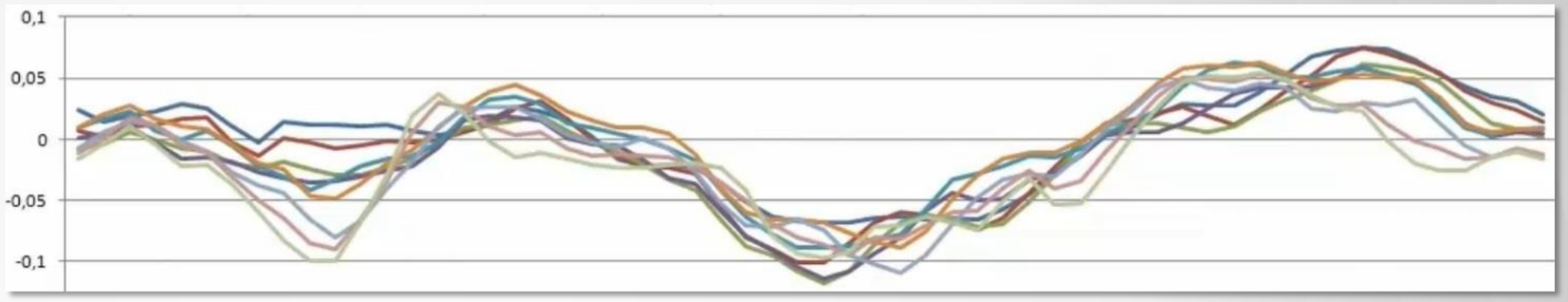
Analysis

- Input Options
  - Distance threshold
  - Grid size
  - Sampling method (i.e. low point, high point, average, etc.)
- Output Options
  - Surface deviation & deformation
  - Raw data to bring into Excel or other reporting software
  - 2D & 3D results created in drawing

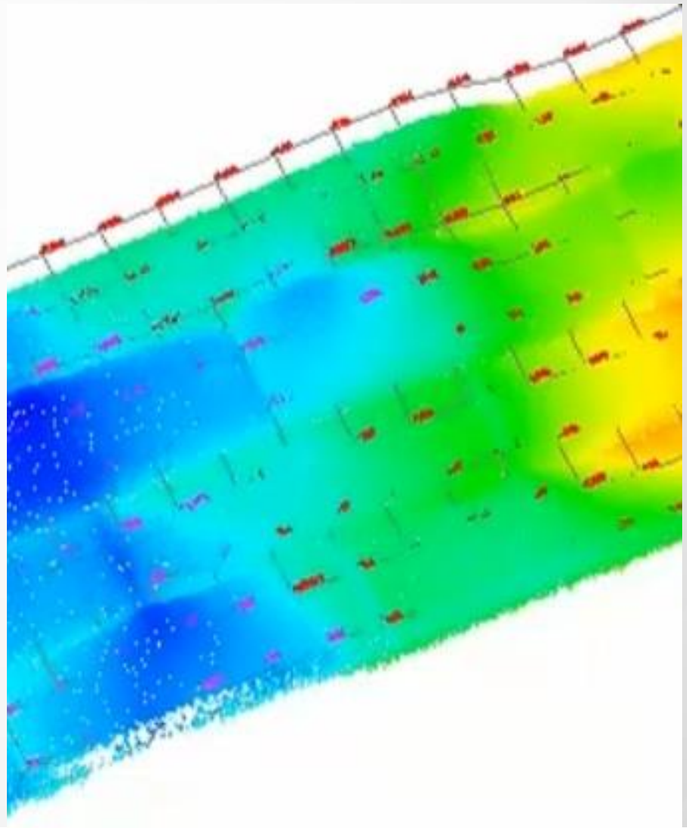


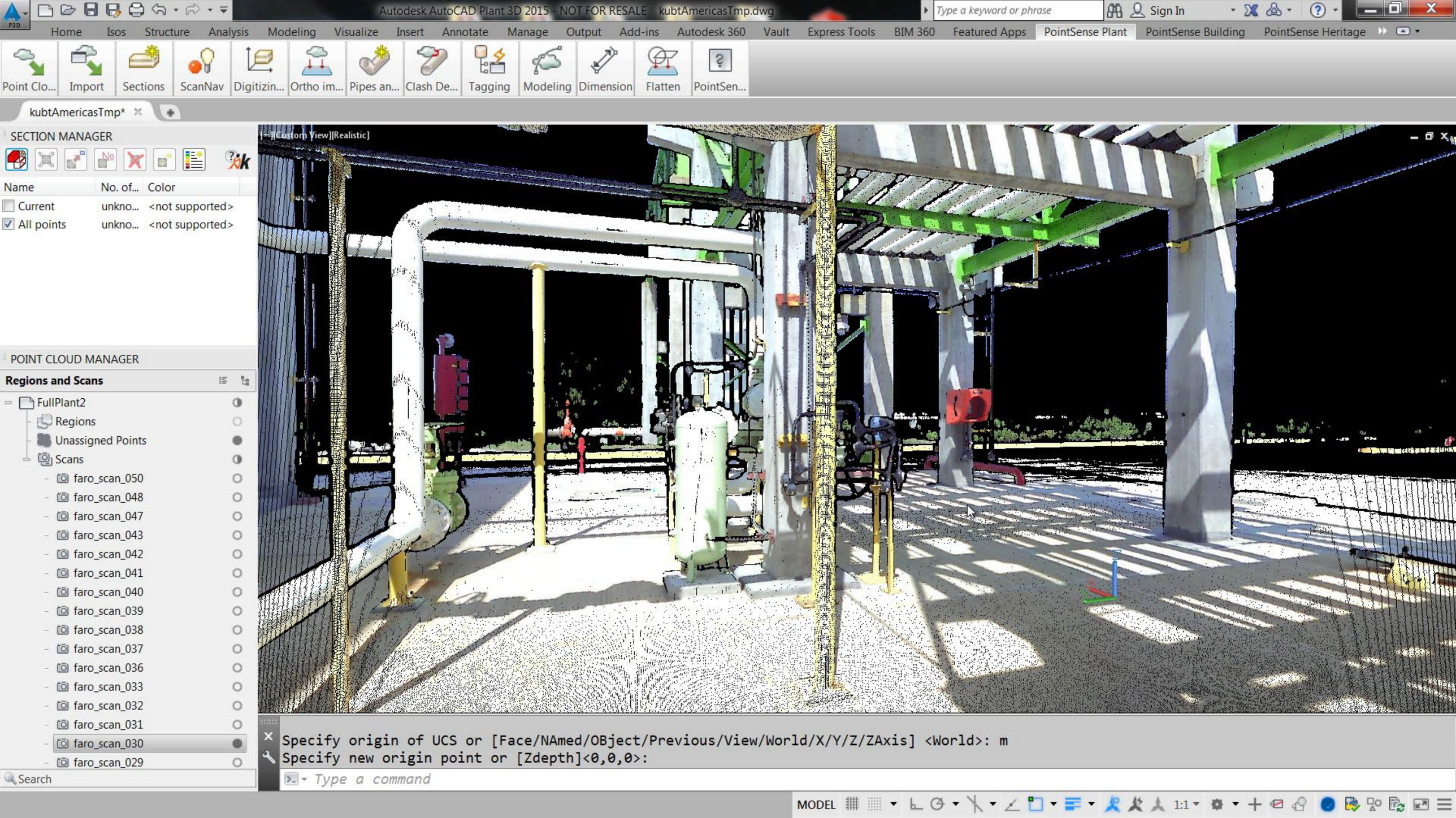


Typical Analysis Applications for Plant



- Planar Analysis
  - Ground analysis
  - Volumes of containment areas around tanks
  - Structural components being plumb or straight
- Cylinder Analysis
  - Volumetrics and surface deformation of tanks
  - Quantifying damage to piping

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Point Clo... Import Sections ScanNav Digitizin... Ortho im... Pipes an... Clash De... Tagging Modeling Dimension Flatten PointSen...
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POINT CLOUD MANAGER
Regions and Scans
FullPlant2
Regions
Unassigned Points
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Session Feedback

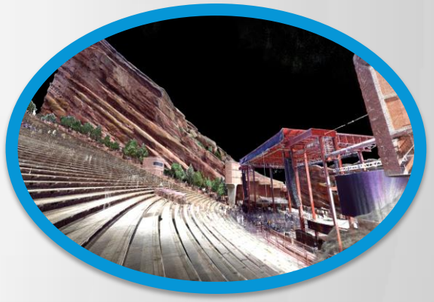
- Via the Survey Stations, email or mobile device
- AU 2014 passes given out each day!
- Best to do it right after the session
- Instructors see results in real-time

QUESTIONS?

Reality Computing @ Autodesk University 2014

- **ReCap Booth #268**
  - ReCap, ReCap 360 and Memento demonstrations
  - 3D origami contest using the CultLab 3D robot scanner!
  - Demonstrations of the best scanning & processing technologies
    - *Tuesd., 6:30 – 7:30 pm: Meet the Reality Computing Hardware!*
    - *Wed., 6:30 – 7:30 pm: Meet the Reality Computing Innovators!*

- **AutoCAD booth #284**
  - ReCap and AutoCAD, the Rockstars of Reality Computing!



- **3D RV booth #300**
  - Learn more about the 3DRV tour
  - Register to REAL 2015, the 1st Reality Computing Conferenc

REAL 2015
CAPTURE ▸ COMPUTE ▸ CREATE


REAL | 2015
CAPTURE > COMPUTE > CREATE

Reality Computing @ Autodesk University 2014

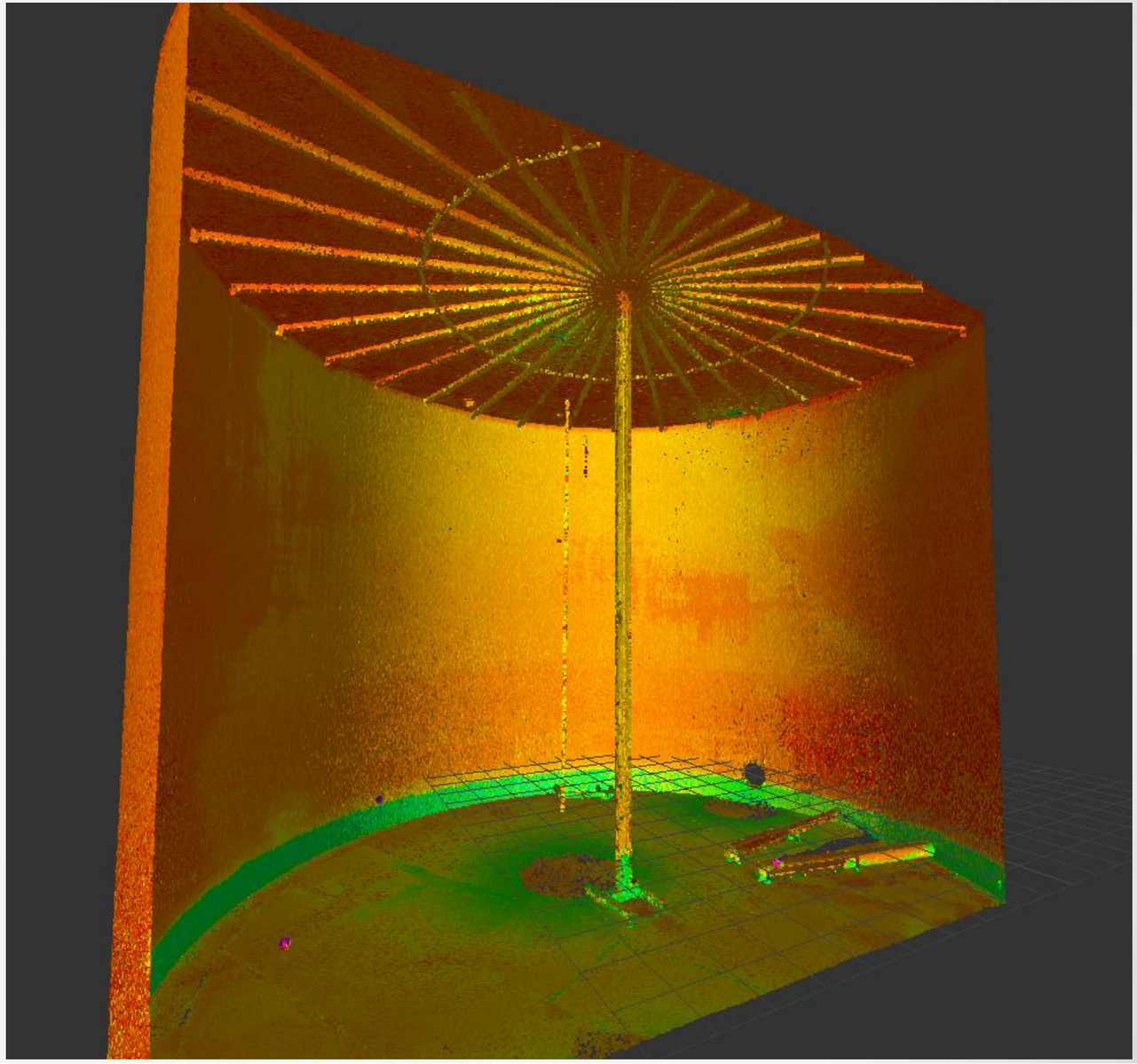
Keynote - Classes - *Activities*	Room	Tuesday 12/2	Wed. 12/3	Thursday 12/4
As-built to BIM: Detailed Reality Computing for Revit - RC6768	**South Seas E**	8:00 am		
Getting the Most out of ReCap - RC 7897L	**Mandalay Bay L**	1:15 pm		
Social involvement in urban planning with laser scanning - RC6799	**South Seas I**	1:30 pm		
Reality Computing: Data from things, things from data, and what goes on in between - RC7376	**South Seas J**	3:00 pm		
Autodesk ReCap Customer Council (per invitation only)	***Islander F***	***4:00 pm***		
Case Studies: Managing 19th Century Architecture with 21st Century Technology - RC5992	**South Seas I**	5:00 pm		
How is Reality Capture impacting BIM - RC6451	**South Seas J**		8:00 am	
Reality Capture = Dramatic ROI! - RC4974	**South Seas J**		10:00 am	
Tips & Tricks to Improve Reality Capture - RC6115	**South Seas I**		1:00 pm	
UAV Demonstration downtown Las Vegas with Skycatch	***Off-site***		***2:30 pm***	
From 3D Scanning to 3D Printing for Integrated Reality Projects - RC6820	**South Seas J**		3:00 pm	
Mastering the Reality with Reality Masters - RC5501	**South Seas J**		4:30 pm	
Extreme Reality Computing from a Hexacopter - RC6731	**Mandalay Bay D**			8:00 am
Laser Scanning - Registration process: Recap Pro vs. Leica Cyclone - RC7342	**South Seas H**			10:00 am
Memento Customer Council (per invitation only)	***Islander E***			***11:30 am***
Getting the Most out of ReCap - RC 5336L - Repeat	**Mandalay Bay A**			1:00 pm
Shirts vs Skins: The Ultimate Reality Capture vs Virtual Model Showdown Panel - RC5635	**South Seas C**			3:00 pm

Project Scope

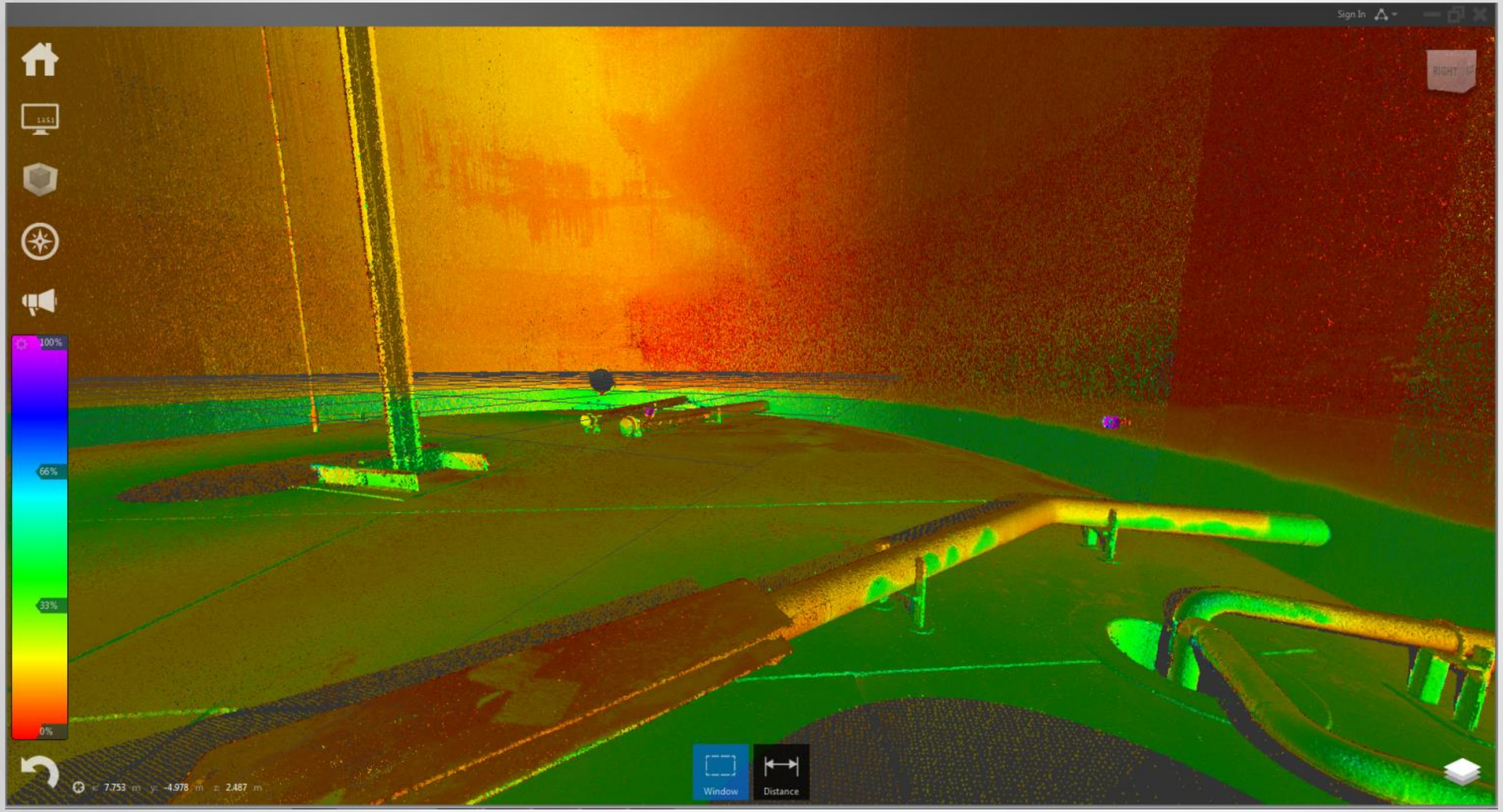
- Document tank surface dimensions
- Contour tank Floor
- Perform varying volume calculations per elevation
- Measure wall contours and deformation
- One field day to collect data

Aaron Hunt
TruePoint Scanning

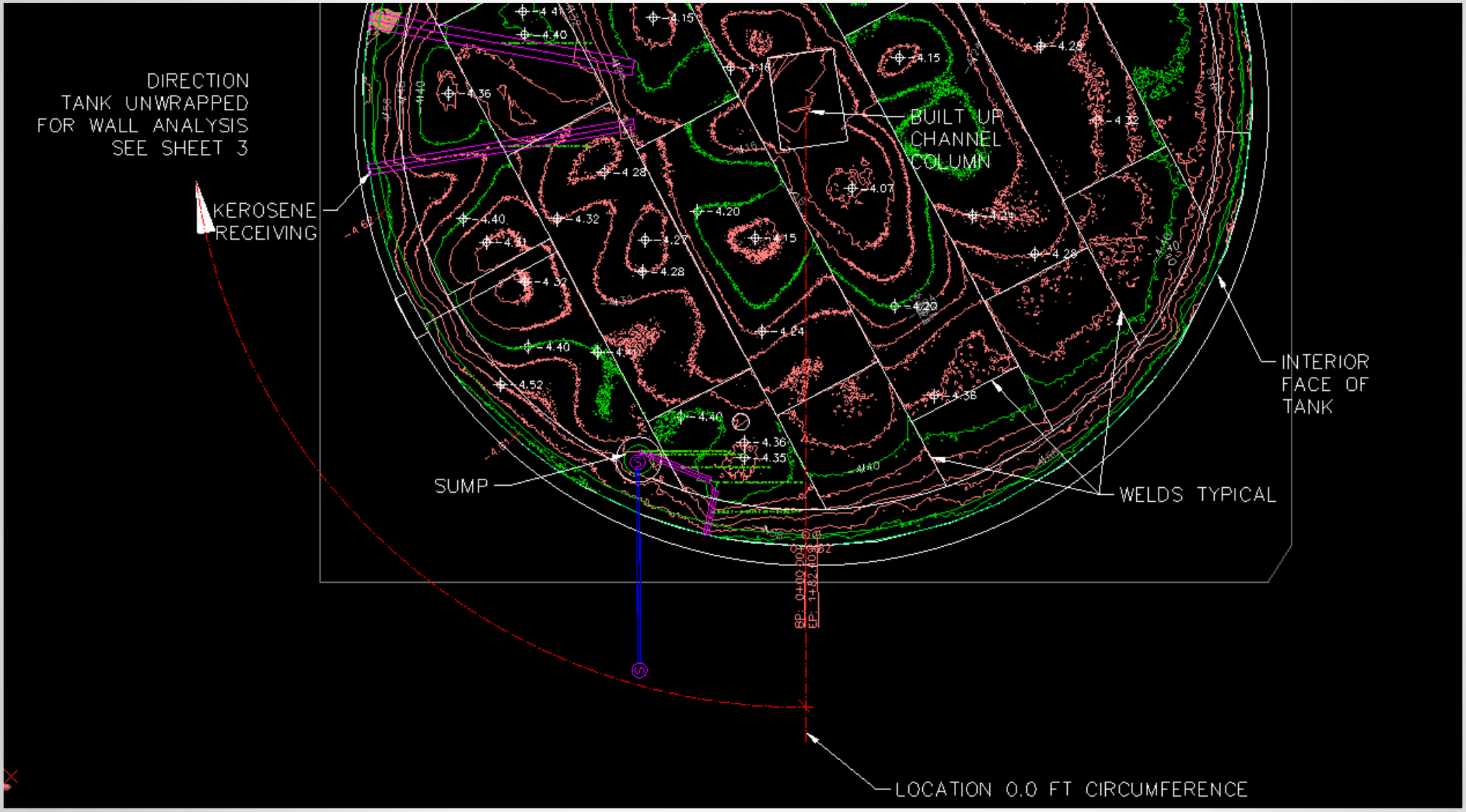
Tank Section



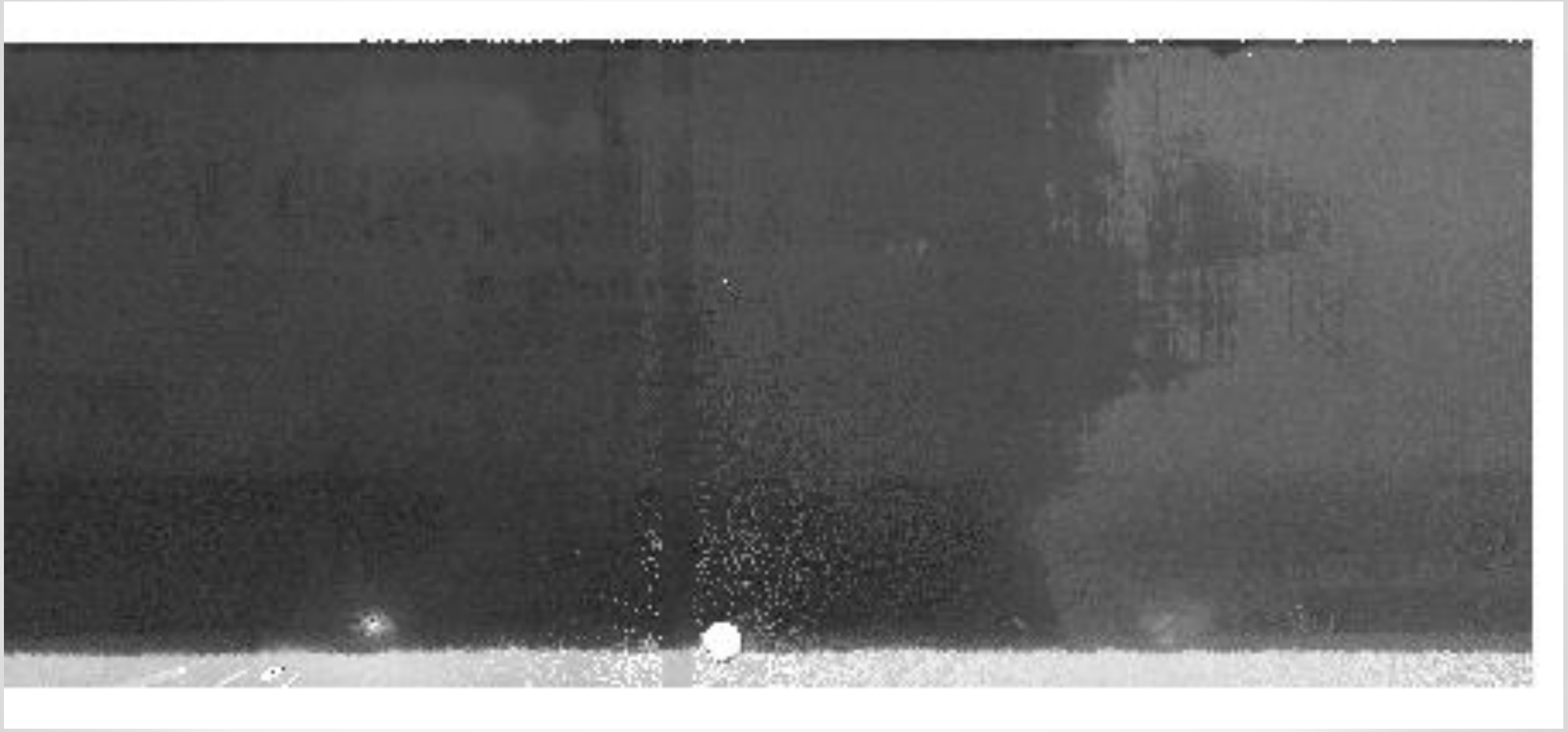
Tank Floor Welds and Pipes



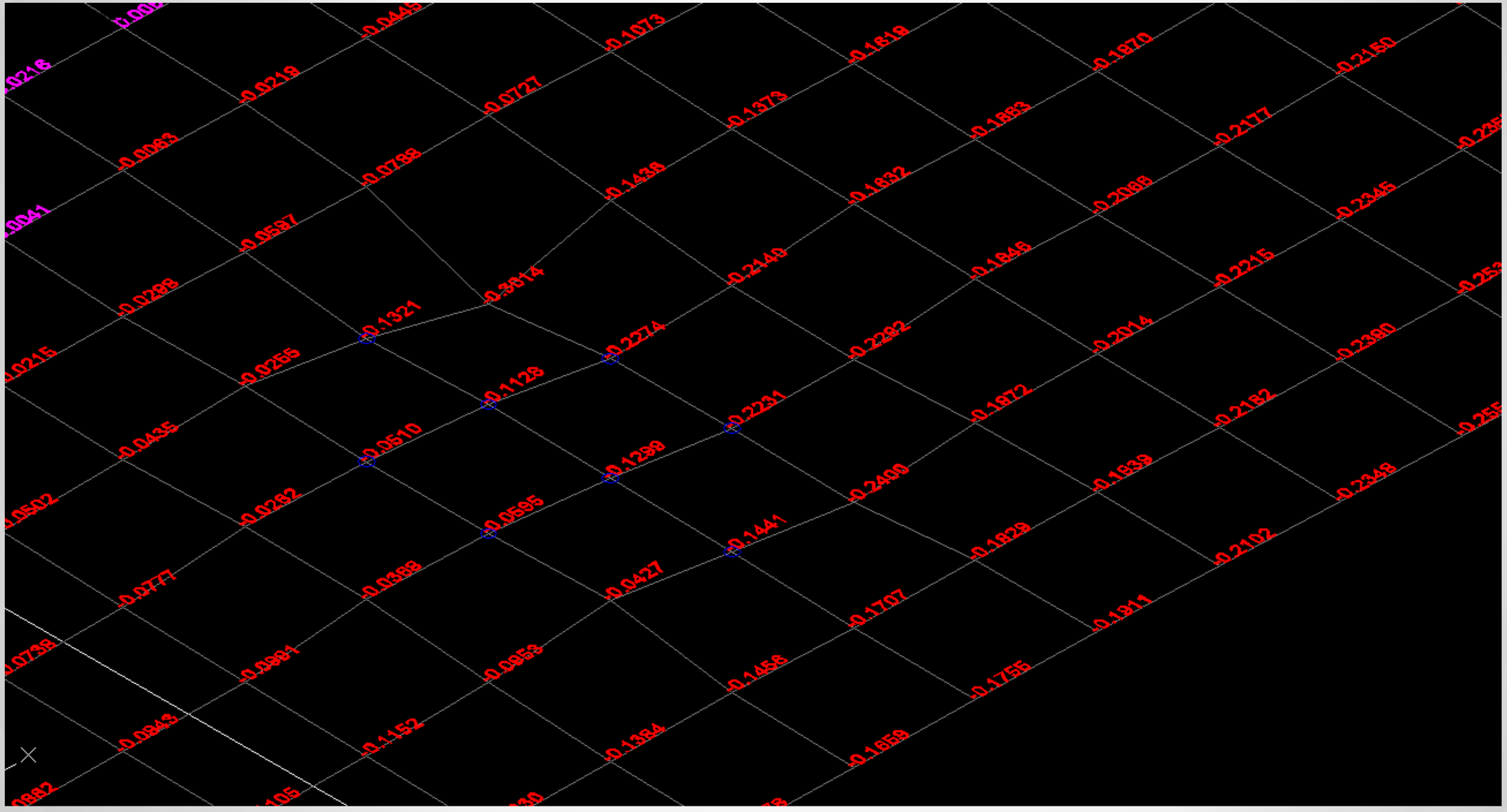
Location of Cylinder cut



Cylinder Wall on Flat Plane



Deviation from Flat Plane



Deviation Data in Excel

54.45°	56.36°	58.27°	60.18°	62.09°	64°	65.91°	67.83°	69.74°	71.65°	73.56°	75.47°	77.38°	79.29°	81.2°	83.11°	85.02°	86.93°	88.84°	90.75°	92.66°	94.57°	96.48°	98.39°	100.3°	102.2°
28.5	29.5	30.5	31.5	32.5	33.5	34.5	35.5	36.5	37.5	38.5	39.5	40.5	41.5	42.5	43.5	44.5	45.5	46.5	47.5	48.5	49.5	50.5	51.5	52.5	53.5
-0.81116	-0.84362	-0.81906	-0.90682	-1.10194	-1.44931	-1.83714	-2.08048	-2.23771	-2.63281	-3.22156	-3.5423	-3.72599	-3.86231	-4.3553	-3.92235	-3.81708	-3.57712	-3.30108	-3.09284	-3.28948	-3.56296	-3.71748	-3.68337	-4.32851	-3.47061
-0.49931	-0.58686	-0.43689	0.806387	0.240433	-0.45652	-1.5889	-1.78845	-1.85625	-2.18604	-2.89257	-3.32229	-3.52687	-3.67195	-3.88029	-3.79725	-3.64429	-3.26946	-2.82596	-2.58006	-2.88776	-3.27571	-3.45628	-3.43007	-3.32865	-3.10457
-0.20284	-0.31179	0.642156	0.858264	0.458211	0.53972	-1.37267	-1.51589	-1.47354	-1.68685	-2.39872	-2.93721	-3.22275	-3.43182	-3.58872	-3.61212	-3.4098	-2.90341	-2.41697	-2.14232	-2.38579	-2.92999	-3.17271	-3.19446	-3.03136	-2.6595
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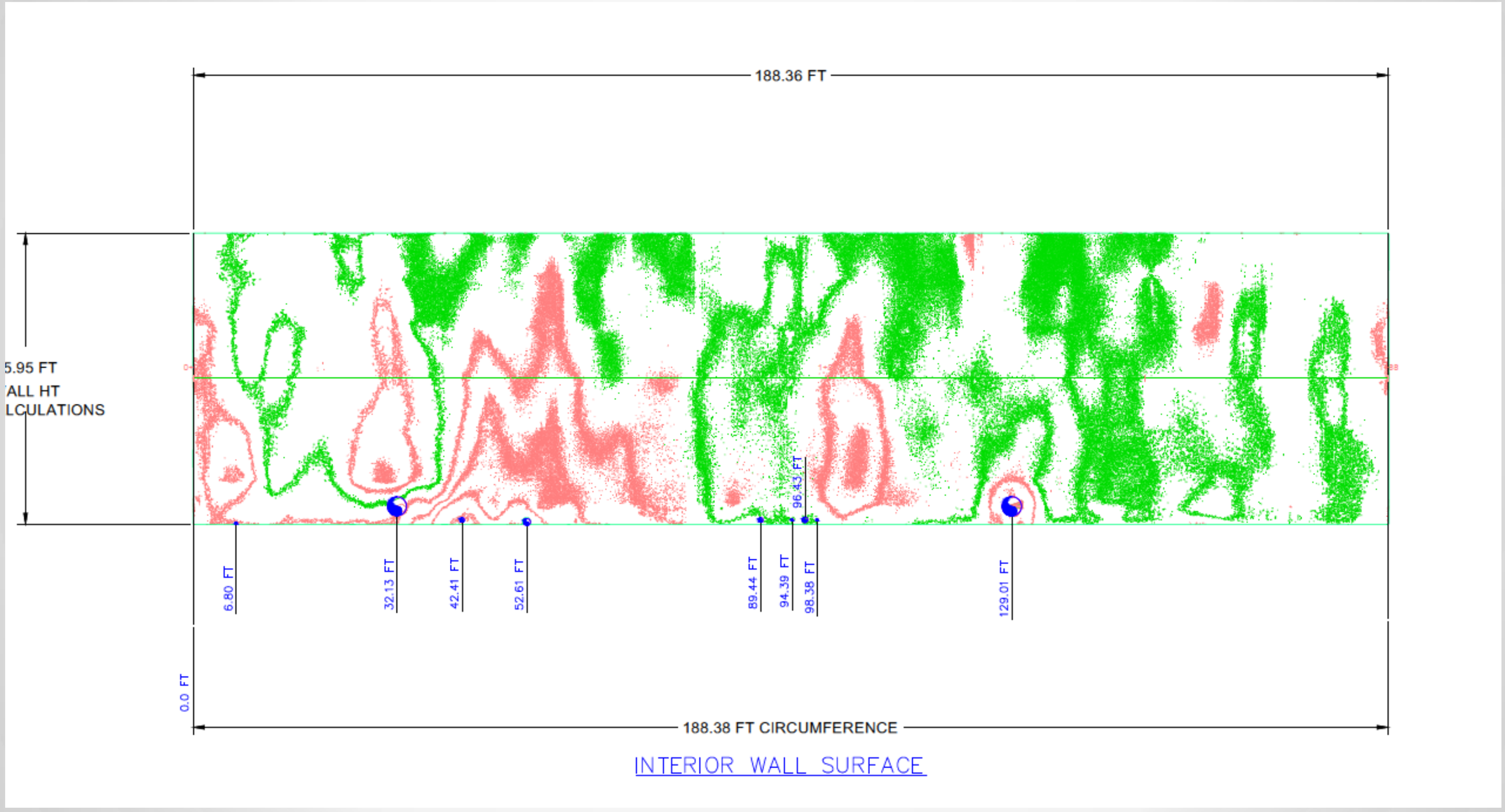
0.609015	0.531154	0.541548	0.513824	0.546803	-0.04399	-0.56377	-0.70557	-0.65157	-0.63809	-0.95427	-1.30497	-1.93238	-2.53662	-2.88441	-2.95964	-2.873	-2.63433	-2.3023	-2.17061	-2.28614	-2.47648	-2.62126	-2.66783	-2.55886	-2.35749
1.070072	1.08844	1.082655	1.008065	0.806545	0.438889	0.044721	-0.16176	-0.2118	-0.23549	-0.54402	-0.96289	-1.55564	-2.14097	-2.52268	-2.67027	-2.69433	-2.63784	-2.44908	-2.26872	-2.28841	-2.36535	-2.43073	-2.44906	-2.39348	-2.29309
1.597895	1.693169	1.720809	1.612052	1.406621	1.082861	0.72338	0.456203	0.323633	0.207388	-0.10632	-0.64793	-1.25293	-1.80618	-2.20617	-2.411	-2.48277	-2.53235	-2.47476	-2.34771	-2.30221	-2.26745	-2.24896	-2.2591	-2.22282	-2.19825
1.774916	1.889243	1.879675	1.786025	1.612992	1.293377	0.991214	0.809001	0.533481	0.385611	0.115231	-0.39696	-0.98491	-1.50761	-1.91042	-2.15688	-2.32327	-2.40714	-2.43345	-2.38588	-2.27872	-2.15658	-2.08716	-2.08349	-2.0883	-2.11661
1.795951	1.8872	1.868467	1.776073	1.611008	1.34692	1.090456	0.982447	0.657111	0.418103	0.086457	-0.33696	-0.83521	-1.31312	-1.6982	-1.97546	-2.19802	-2.33757	-2.3839	-2.33188	-2.20115	-2.05676	-1.9751	-1.95748	-1.98101	-2.02722
1.769332	1.830262	1.798322	1.698854	1.553586	1.321867	1.061983	0.890882	0.594201	0.376321	0.044316	-0.31943	-0.74077	-1.1761	-1.54734	-1.84413	-2.09178	-2.25673	-2.30916	-2.25032	-2.11425	-1.96237	-1.88572	-1.88178	-1.9068	-1.94806
1.693727	1.757504	1.72854	1.63043	1.482949	1.274854	1.025998	0.818041	0.537352	0.319592	0.022775	-0.30278	-0.68064	-1.07816	-1.44154	-1.75232	-2.01522	-2.20569	-2.28797	-2.23811	-2.10945	-1.96192	-1.8686	-1.83044	-1.85162	-1.90655
1.626055	1.679273	1.658698	1.559989	1.411449	1.21207	0.976838	0.752549	0.4814	0.297543	0.028331	-0.26841	-0.61634	-0.98357	-1.33867	-1.64319	-1.93033	-2.13978	-2.23522	-2.19729	-2.07172	-1.91616	-1.81464	-1.78121	-1.80365	-1.88469
1.564295	1.607691	1.589849	1.477262	1.316882	1.13322	0.908814	0.64445	0.404789	0.278012	0.058421	-0.23666	-0.5674	-0.91677	-1.24823	-1.55269	-1.84587	-2.06656	-2.16561	-2.14013	-2.01308	-1.86703	-1.76286	-1.73539	-1.79071	-1.89257
1.502742	1.550098	1.528324	1.403615	1.222281	1.041302	0.835847	0.561784	0.330675	0.236839	0.033143	-0.23182	-0.54455	-0.85595	-1.17847	-1.4812	-1.78758	-2.00888	-2.10187	-2.06462	-1.95543	-1.81825	-1.74146	-1.75075	-1.80251	-1.84045
1.423975	1.488593	1.47681	1.332657	1.119142	0.935392	0.755332	0.553816	0.387818	0.26578	0.039671	-0.18947	-0.46299	-0.77365	-1.10071	-1.41038	-1.72425	-1.97948	-2.05239	-1.99378	-1.87407	-1.76012	-1.73383	-1.7474	-1.70325	-1.72608
1.377096	1.473866	1.485358	1.366228	1.171306	1.005515	0.802751	0.641226	0.511606	0.322382	0.089868	-0.12392	-0.37275	-0.6721	-1.03386	-1.35953	-1.69484	-2.01436	-2.10371	-1.98842	-1.84144	-1.74856	-1.68483	-1.55231	-1.48609	-1.52801
1.296021	1.423104	1.470419	1.380445	1.21866	1.062223	0.870677	0.693857	0.534871	0.334041	0.117052	-0.09438	-0.34762	-0.62693	-0.95231	-1.27624	-1.60921	-1.90236	-2.02365	-1.96033	-1.85121	-1.74843	-1.52078	-1.36362	-1.33177	-1.39489
1.173618	1.329875	1.408838	1.346351	1.213653	1.06772	0.879985	0.687596	0.504268	0.304615	0.099952	-0.10745	-0.34652	-0.60202	-0.90177	-1.20678	-1.53159	-1.82608	-1.97376	-1.96512	-1.88982	-1.65959	-1.37968	-1.26752	-1.26162	-1.32357
1.052303	1.238219	1.345246	1.305047	1.196061	1.052254	0.869563	0.672685	0.472929	0.276189	0.068418	-0.12957	-0.3603	-0.59434	-0.86329	-1.15288	-1.46449	-1.77547	-1.9571	-1.94977	-1.80023	-1.53639	-1.28833	-1.20079	-1.20402	-1.27354
0.942065	1.150241	1.281559	1.255296	1.153707	1.021845	0.848291	0.651747	0.445205	0.233693	0.042764	-0.15506	-0.36817	-0.57769	-0.83438	-1.1037	-1.4221	-1.73629	-1.90869	-1.86638	-1.6758	-1.44154	-1.18962	-1.1172	-1.14207	-1.22714
0.852091	1.064024	1.202553	1.188674	1.106525	0.987042	0.821616	0.636117	0.415787	0.198107	0.00758	-0.17708	-0.38053	-0.56332	-0.80195	-1.08079	-1.41287	-1.69258	-1.79906	-1.72222	-1.57886	-1.35684	-1.10055	-1.03469	-1.07885	-1.16653
0.773104	0.963249	1.089864	1.101289	1.044371	0.930727	0.783564	0.608817	0.387046	0.157483	-0.04188	-0.22916	-0.4119	-0.58931	-0.82219	-1.10792	-1.42302	-1.60349	-1.69035	-1.6738	-1.52712	-1.30601	-1.05976	-0.99918	-1.03097	-1.13015
0.754498	0.90229	1.027418	1.044385	0.994125	0.889075	0.760474	0.592672	0.366687	0.141092	-0.06489	-0.22464	-0.40227	-0.6065	-0.86983	-1.13907	-1.31346	-1.4726	-1.61165	-1.63342	-1.49038	-1.26441	-1.0355	-0.93077	-0.97418	-1.0833
0.787094	0.913233	1.030847	1.013187	0.942199	0.83246	0.675074	0.492384	0.281912	0.065767	-0.10315	-0.20278	-0.38309	-0.6386	-0.89944	-1.06725	-1.25054	-1.44037	-1.59228	-1.52809	-1.3368	-1.12732	-0.95143	-0.85621	-0.8955	-0.97015
0.817661	0.961402	1.064054	1.025744	0.930163	0.810105	0.646837	0.448403	0.239764	0.055945	-0.08516	-0.20909	-0.40349	-0.62723	-0.76637	-0.92659	-1.16164	-1.36986	-1.46013	-1.32522	-1.14029	-0.97394	-0.85336	-0.79172	-0.81066	-0.86353
0.831109	0.975445	1.063706	1.009941	0.8966	0.762271	0.577953	0.383273	0.189119	0.013978	-0.1375	-0.28247	-0.45259	-0.54186	-0.65763	-0.85736	-1.1039	-1.29139	-1.3399	-1.17341	-1.00451	-0.87481	-0.81023	-0.77	-0.7932	-0.83281
0.83866	0.99347	1.086098	1.016163	0.87059	0.705188	0.515665	0.33999	0.143793	-0.06176	-0.24615	-0.35399	-0.38798	-0.43882	-0.59114	-0.81278	-1.04181	-1.19667	-1.21473	-1.03162	-0.88676	-0.78566	-0.76425	-0.75993	-0.77997	-0.82776
0.862445	1.041995	1.143057	1.047762	0.850438	0.652574	0.460736	0.29076	0.079544	-0.15334	-0.31054	-0.28468	-0.28505	-0.37934	-0.56147	-0.7797	-0.98251	-1.09282	-1.10505	-0.91739	-0.78244	-0.69678	-0.6969	-0.71404	-0.75883	-0.80106
0.889287	1.075266	1.172783	1.058809	0.835509	0.608973	0.384932	0.186548	-0.05748	-0.24045	-0.26351	-0.19536	-0.24226	-0.36144	-0.52972	-0.73098	-0.91782	-1.00871	-0.97644	-0.80536	-0.67811	-0.62075	-0.61745	-0.66197	-0.72867	-0.77872
0.904509	1.08126	1.159878	1.033373	0.807771	0.540334	0.25999	-0.01151	-0.21065	-0.25621	-0.21916	-0.17407	-0.25382	-0.37642	-0.51874	-0.68466	-0.86922	-0.92919	-0.84208	-0.73746	-0.6142	-0.57685	-0.57793	-0.64532	-0.71399	-0.77118
0.897832	1.056584	1.108635	0.986372	0.733327	0.432289	0.105977	-0.16766	-0.26508	-0.28921	-0.23827	-0.17938	-0.23053	-0.34908	-0.52171	-0.6694	-0.80135	-0.82479	-0.73621	-0.61711	-0.5673	-0.54915	-0.55928	-0.61378	-0.72186	-0.8233
0.944303	1.125182	1.147901	1.02353	0.70007	0.323852	0.03066	-0.09956	-0.12267	-0.1496	-0.14861	-0.08985	-0.12603	-0.26765	-0.45098	-0.59135	-0.69056	-0.72198	-0.63451	-0.55842	-0.51285	-0.49274	-0.47721	-0.53694	-0.70616	-0.85061
0.943455	1.145519	1.155442	0.960587	0.592009	0.288675	0.132786	-0.00281	-0.00494	-0.02222	-0.03118	-0.00781	-0.06322	-0.20184	-0.3747	-0.50146	-0.59724	-0.61966	-0.55062	-0.5079	-0.46538	-0.43306	-0.41439	-0.46827	-0.63494	-0.79358
0.905398	1.111981	1.083489	0.823402	0.480131	0.312749	0.193013	0.00229	0.01802	0.009291	0.003825	0.001717	-0.05879	-0.17976	-0.32771	-0.44683	-0.52585	-0.54771	-0.51393	-0.46768	-0.43012	-0.40907	-0.39506	-0.44553	-0.59519	-0.75311
0.867881	1.035549	0.968881	0.699047	0.463148	0.334699	0.179222	-0.0052	0.019776	0.016788	0.002384	0.002169	-0.05427	-0.15149	-0.27597	-0.38639	-0.47174	-0.48789	-0.48443	-0.44456	-0.39956	-0.37935	-0.36833	-0.40866	-0.56121	-0.73209
0.799486	0.92101	0.86447	0.699109	0.472466	0.30124	0.118818	-0.03551	0.014252	0.019036	-0.00027	0.011647	-0.02719	-0.10182	-0.2114	-0.32038	-0.39927	-0.43085	-0.44601	-0.40248	-0.36931	-0.34201	-0.32481	-0.34803	-0.50911	-0.7114
0.693091	0.814348	0.860036	0.723193	0.454809	0.234345	0.069729	-0.03398	0.017175	0.015134	0.007127	0.022096	-0.00383	-0.05731	-0.14163	-0.24083	-0.31819	-0.36059	-0.40308	-0.32474	-0.30466	-0.28149	-0.25555	-0.29188	-0.45296	-0.67371
0.583556	0.777759	0.842232	0.689027	0.384577	0.142436	0.016801	-0.02788	-0.00431	-0.01534	-0.0156	0.007853	-0.01821	-0.04862	-0.08651	-0.16782	-0.24931	-0.31225	-0.39618	-0.30928	-0.2767	-0.24525	-0.20896	-0.2569	-0.41814	-0.66234
0.509354	0.720778	0.755385	0.580588	0.277468	0.062364	-0.05975	-0.07545	-0.02023	-0.00333	0.012266	0.03881	0.002534	-0.04132	-0.08953	-0.16928	-0.27145	-0.35248	-0.41588	-0.3648	-0.28573	-0.23351	-0.2029	-0.26181	-0.40459	-0.62321
0.437723	0.625705	0.72873	0.551959	0.309877	0.129573	0.010654	-0.01921	0.001938	0.066933	0.077547	0.068893	0.046924	0.00534	-0.07765	-0.14087	-0.25337	-0.34972	-0.40395	-0.41381	-0.31473	-0.2327	-0.206	-0.26039	-0.38927	-0.58455
0.465975	0.609647	0.69485	0.514606	0.285405	0.131219	0.035255	0.017321	0.045187	0.098629	0.117715	0.117414	0.115619	0.079484	-0.00693	-0.08434	-0.18801	-0.26509	-0.35504	-0.36249	-0.30069	-0.21646	-0.1459	-0.19027	-0.30823	-0.46466
0.43615	0.562754	0.623497	0.453554	0.217458	0.095108	0.02848	0.014831	0.054503	0.10996	0.150085	0.163738	0.153742	0.120319	0.040343	-0.04533	-0.14598	-0.22334	-0.30634	-0.34199	-0.29604	-0.22257	-0.15188	-0.16303	-0.25682	-0.38429
0.400856	0.502563	0.555564	0.397506	0.182895	0.089096	0.028086	0.020277	0.064186	0.127705	0.197616	0.21504	0.198054	0.164011	0.090858	0.010511	-0.09675	-0.17823	-0.26578	-0.33007	-0.29212	-0.2356	-0.1571	-0.13902	-0.21513	-0.34423
0.364951	0.443949	0.489501	0.339485	0.153362	0.086122	0.035547	0.024053	0.059427	0.138292	0.243193	0.272308	0.254194	0.214014	0.1454	0.058874	-0.04221	-0.11931	-0.19804	-0.28407	-0.29669	-0.24576	-0.15281	-0.1017	-0.15274	-0.29697
0.353589	0.415874	0.420189	0.269603	0.139759	0.111229	0.06104	0.043859	0.085183	0.169515	0.287905	0.36708	0.349062	0.295385	0.219414	0.127835	0.043597	-0.00903	-0.11781	-0.20864	-0.24592	-0.19677	-0.11989	-0.03204	-0.06132	-0.20212
0.217557	0.308283	0.272806	0.110594	-0.00264	-0.14228	-0.00677	0.01753	0.064481	0.154167	0.283684	0.044802	0.368789	0.311312	0.247939	0.148962	0.053606	-0.26926	-0.17139	-0.25606	-0.29363	-0.23604	-0.1425	-0.0103	-0.21204	-0.1285

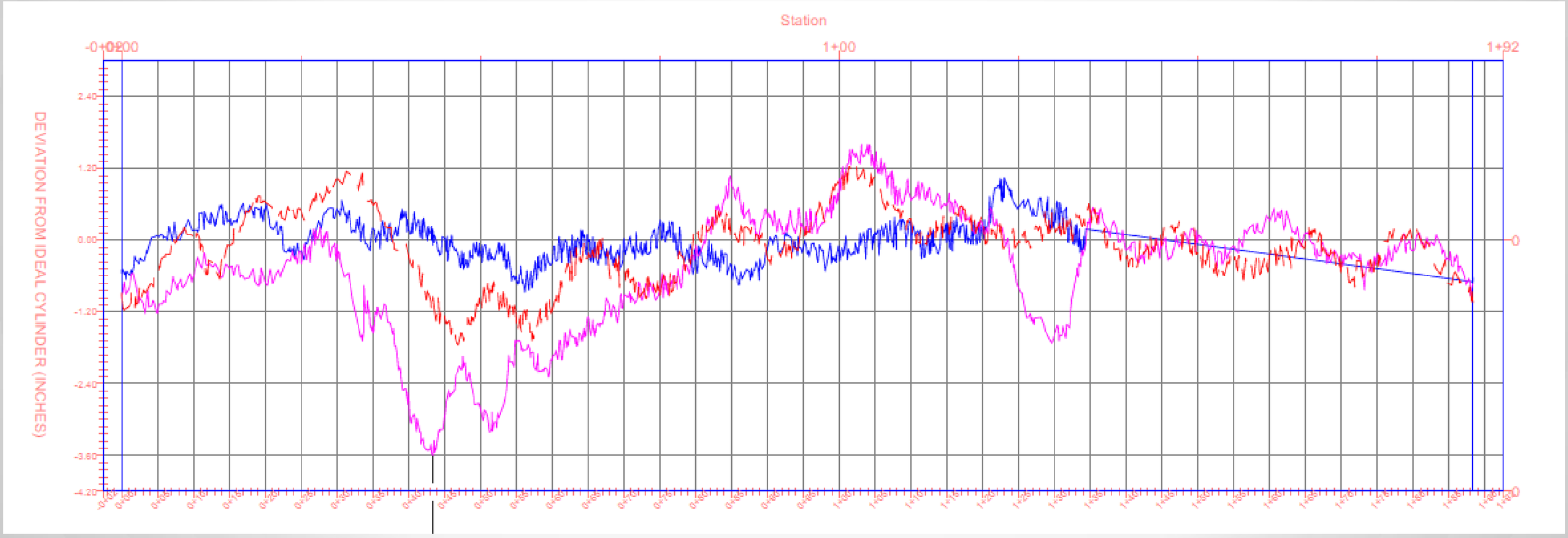
Volume Output

angle		352.5°	354.4°	356.3°	358.2°	360.1°		
arc length/height		184.5	185.5	186.5	187.5	188.5	circumference	slice volume
0.4826	0.9	-0.0308	-0.0416	-0.0521	-0.0625	-0.0612	187.9945244	1405.806936
1.483	1.9	-0.0181	-0.0311	-0.0444	-0.0579	-0.0614	187.9945244	2790.48878
2.483	2.9	-0.0148	-0.0267	-0.0423	-0.0603	-0.0682	188.1211543	2815.887838
3.483	3.9	-0.0150	-0.0249	-0.0398	-0.0603	-0.0716	188.2477693	2816.619664
4.483	4.9	-0.0132	-0.0217	-0.0344	-0.0510	-0.0614	188.6029531	2819.135124
5.483	5.9	-0.0129	-0.0186	-0.0279	-0.0380	-0.0469	188.2548963	2819.631174
6.483	6.9	-0.0108	-0.0149	-0.0188	-0.0251	-0.0334	188.2765044	2820.749053
7.483	7.9	-0.0114	-0.0124	-0.0148	-0.0202	-0.0311	188.3247965	2821.784345
8.483	8.9	-0.0079	-0.0099	-0.0150	-0.0253	-0.0387	188.3459383	2822.373308
9.483	9.9	-0.0067	-0.0106	-0.0204	-0.0337	-0.0447	188.3614845	2822.759364
10.48	10.9	-0.0081	-0.0147	-0.0268	-0.0418	-0.0527	188.3674895	2822.864269
11.48	11.9	-0.0095	-0.0189	-0.0324	-0.0467	-0.0560	188.3653974	2822.881492
12.48	12.9	-0.0136	-0.0246	-0.0379	-0.0509	-0.0585	188.3665133	2822.932267
13.48	13.9	-0.0179	-0.0283	-0.0409	-0.0534	-0.0609	188.3671482	2822.915177
14.48	14.9	-0.0208	-0.0294	-0.0394	-0.0508	-0.0584	188.3640907	2822.872164
15.48	15.9	-0.0213	-0.0265	-0.0339	-0.0432	-0.0509	188.3632448	2822.870949
16.48	16.9	-0.0206	-0.0258	-0.0328	-0.0409	-0.0489	188.3633671	2823.152729
17.48	17.9	-0.0236	-0.0301	-0.0377	-0.0472	-0.0533	188.3812287	2823.500641
18.48	18.9	-0.0267	-0.0354	-0.0430	-0.0530	-0.0567	188.3853563	2823.550977
19.48	19.9	-0.0303	-0.0395	-0.0471	-0.0579	-0.0620	188.3837901	2823.523501
20.48	20.9	-0.0350	-0.0441	-0.0520	-0.0626	-0.0692	188.3832871	2823.503886
21.48	21.9	-0.0415	-0.0492	-0.0581	-0.0689	-0.0747	188.3824507	2823.339672
22.48	22.9	-0.0445	-0.0539	-0.0613	-0.0710	-0.0775	188.3725123	2823.090208
23.48	23.9	-0.0430	-0.0527	-0.0592	-0.0672	-0.0751	188.3659997	2823.072384
24.48	24.9	-0.0393	-0.0511	-0.0602	-0.0691	-0.0758	188.3723187	2823.408594
25.48	25.9	-0.0390	-0.0539	-0.0658	-0.0746	-0.0824	188.3896095	2823.667946
26.48	26.9	-0.0400	-0.0574	-0.0724	-0.0791	-0.0849	188.3892965	2823.62881
27.48	27.9	-0.0431	-0.0605	-0.0754	-0.0821	-0.0869	188.3860936	2823.593234
28.48	28.9	-0.0442	-0.0621	-0.0765	-0.0840	-0.0909	188.3866352	2823.642197
29.48	29.9	-0.0453	-0.0645	-0.0792	-0.0872	-0.0942	188.3897182	2823.544293
30.48	30.9	-0.0453	-0.0655	-0.0804	-0.0888	-0.0956	188.3810805	2823.231983

Deviation Contours



Wall Profile



Project Summary

- Quick data collection
- Highly accurate volume calculation
- Provide completely new deliverables to client
- Fabrication and Design savings