OG10279

Field to Finish: Point Cloud to AutoCAD Plant 3D

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Learning Objectives

- Learn how to use laser scans workflows within the 2016 Plant Design Suite
- Learn how to extract as-built deliverables from laser scan data
- Discover how to prepare laser scan projects
- Learn from user experiences regarding converting point cloud

Description

Laser scanning and point clouds are quickly becoming essential tools in the engineering/design/construction workflow. This class will examine real-world scenarios that will show you how to create workflows using Plant Design Suite 2016 software and (FARO) PointSense Plant software (Formerly Kubit). It will also show how to create intelligent piping models, including spec-driven piping and structural design, tie-in point extraction, clash reporting, isometrics, and equipment all from point clouds. This class will give you a solid foundation for how to turn your laser scans into accurate construction drawings.

Your AU Experts

Hung Nguyen *has 22 years of experience in Autodesk Products. He has a strong background in Architectural, Mechanical, Plant design, and Manufacturing fields. His is a Building & Manufacturing & Plant Solutions Technical Consultant. Hung has extensive experience in Manufacturing, Plant, Mechanical Design, Architectural, Structural detailing, and a diverse range of CAD-related software: Revit, Inventor, Plant3D, P&ID, Tekla, and Simulation to name a few. He is Autodesk Certified Instructor (ACI) and have presented at Revit Technology Conference (RTC) and Architecture Festival.*

Irene Radcliffe *has over 25 years of experience in the Oil & Gas industry as both a piping designer and software administrator. She began working with the AutoCAD Plant 3D in 2010, when she was invited to join a team of content developers who were assisting the Autodesk plant development team during the software's early releases. Irene currently works for Cansel as a Technical Consultant for Autodesk business, providing support, training and implementation for Autodesk products in Alberta's Oil and Gas sector.*

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Introduction

In this session, we have brought together key industry experts to present workflows that take you through the Scan to Plant 3D workflow.

- Hung Nguyen (Cansel) will talk about the point cloud registration in Scene.
- Matt Daly (Faro) will tell us a little about the scanners.
- Irene Radcliffe (Cansel) will show us how to use the scan data to produce engineering documents.

By showing you the latest technology, and sharing our experiences, we hope to encourage you to look at your existing workflows, and see the benefits of incorporating laser scanning into your as-built process.

How laser scans workflows fit in 2015 Plant Design Suite

What is Reality Computing as related to plant design?
Reality Computing is a process that involves with three stages: **Capture Data**, **Process Data**, **and Drafting or Modeling deliverables**.

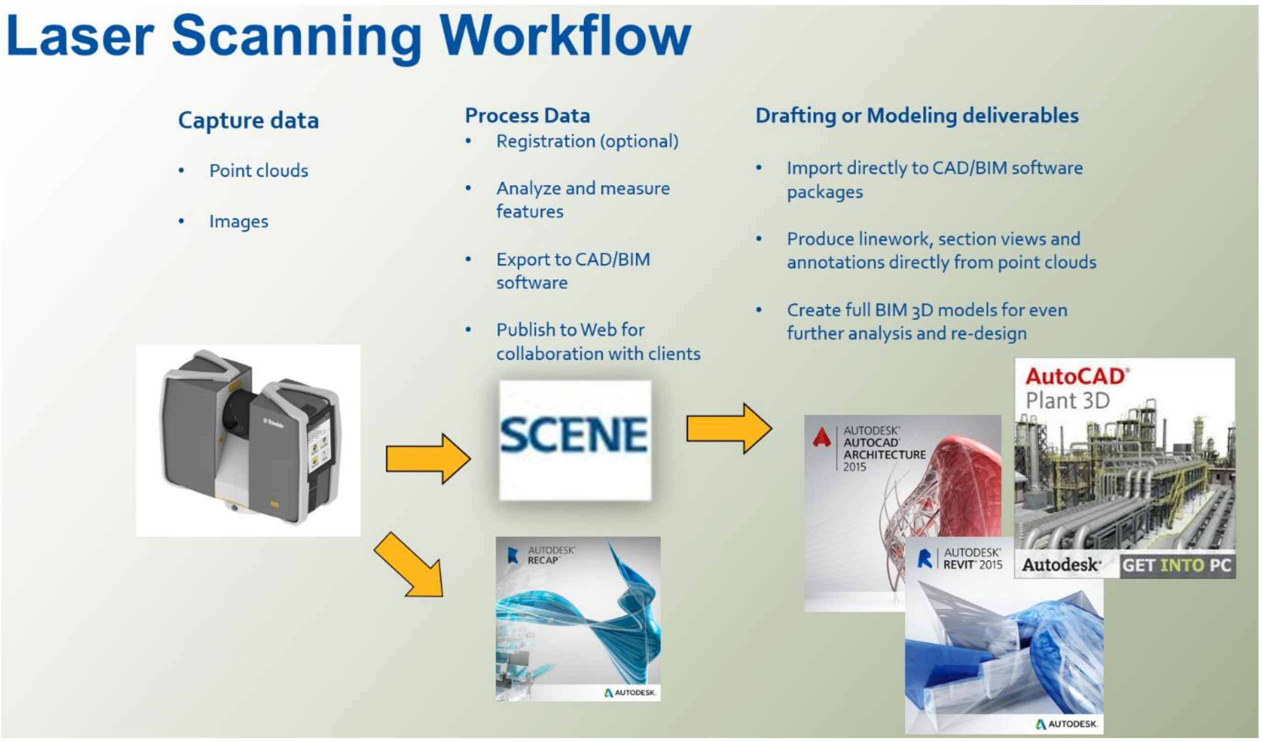


Figure 1: Laser Scanning Workflow

Capture Data
Capture refers to collecting existing field conditions with the use of surveying instruments and/or digital cameras (photogrammetry). Capture involves selecting a device. There are many different devices that can be called 3D scanners. Any device that measures the physical world using lasers, lights or x-rays, and generates dense point clouds or polygon meshes, can be considered a 3D scanner. They go by many names, including 3D digitizers, laser scanners, white light scanners, industrial CT, LIDAR, and others. The common uniting factor of all these devices is that they capture the geometry of physical objects with hundreds of thousands or millions of measurements. *Figure 2* below demonstrates the basic process of laser scan data collection.

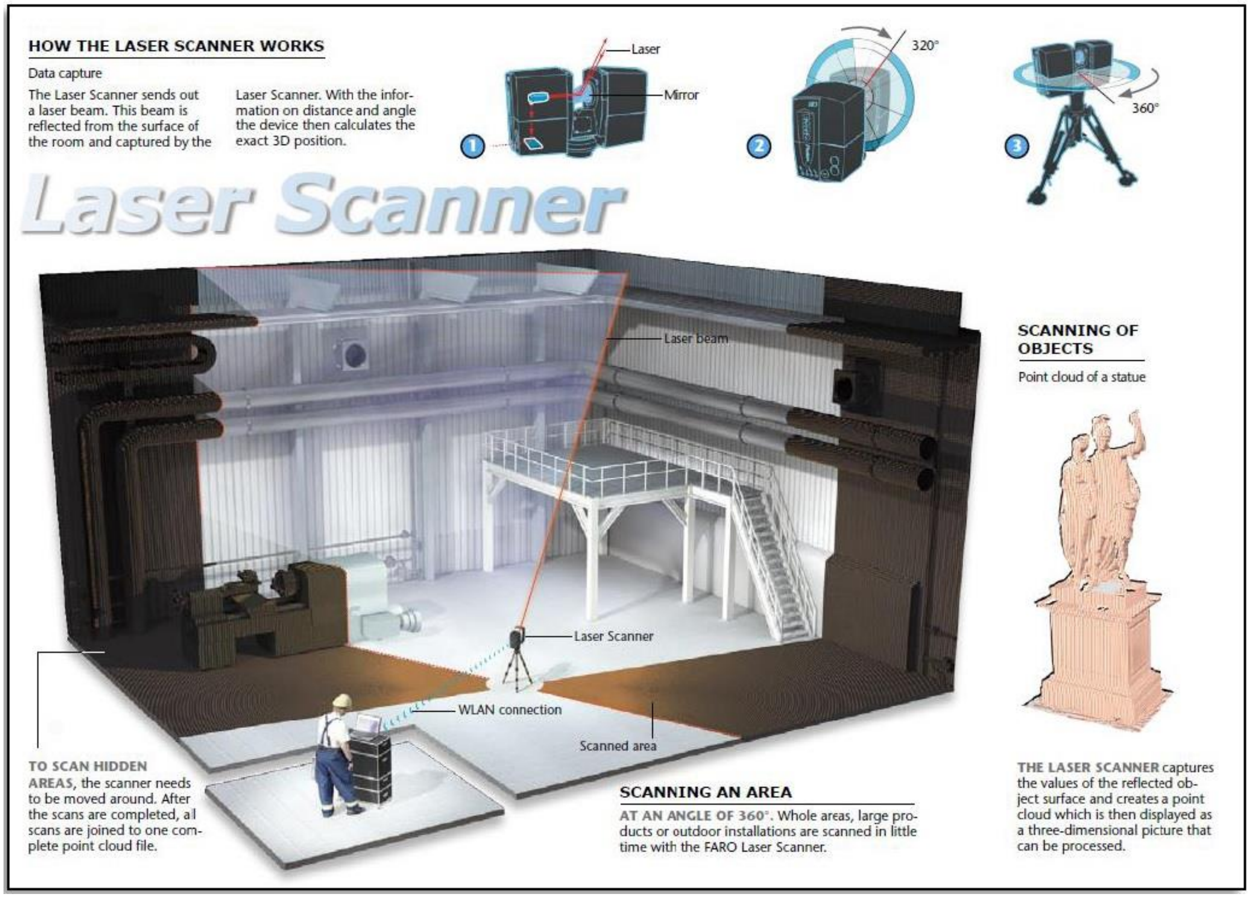


Figure 2: Laser Scanning Process

There are many different approaches to 3D scanning, based on different principles of imaging. Some technologies are ideal for short-range scanning, while others are better for mid- or long-range scanning.

The smallest and lightest laser scanners on the market is FARO's Focus3D X Series. These Scanners are ideal tools for indoor and outdoor applications. The fast and accurate Focus3D scanners offer everything you might expect from professional 3D laser scanners – with FARO's established and well-known level of simplicity.

Focus3D X 330 offers extra-long range - 330m and Focus3D X 130 is a mid-range device offering precise scanning up to 130m.

Both scanner models are equipped with GPS and offer the possibility to perform scanning even in bright sunlight. Remote scanning as well as almost limitless scan data sharing via SCENE Webshare Cloud make the laser scanning solution truly mobile.

Today we are seeing the emergence of image based technologies which use multi-view photogrammetry or structure from motion technology (in combination with powerful servers) to generate point clouds from photos. Because scanning in the industrial environment typically requires tighter tolerances and higher levels of accuracy these additional technologies may require further development and research before they are accepted as "accurate enough" based on the desired deliverables required.

Best Practices in Laser Scanning

When done right, laser scanning can prove beneficial to all stakeholders throughout the life cycle of a project. In general, best practice for good laser scanning will involve with these:

- Identify the intended use of the laser scan data
- Understand the physical space where laser scanning is being applied
- Know the scanning project scope
- Determine the required deliverable
- Establish project survey control before you start scanning
- Collect more data than you need
- Use experienced laser scanning team

Usually, sites that are going to be documented with a 3D laser scanner have been previously documented in one form or another. It is helpful to collect these original forms of documentation, and use them as the foundation for data capture planning. Some examples of existing documentation are existing Historic American Building Survey. Drawings, copies of original blueprints or construction documents, even satellite images of a site captured through Google Maps can be useful in the data capture planning stage. However, it is important to note, that nothing ever is constructed according to plan, and many of these records may be obsolete in one fashion or another. *Figure 3* below demonstrates how the scanner is set up to collect data from multiple locations on the interior as well as the exterior of the building.

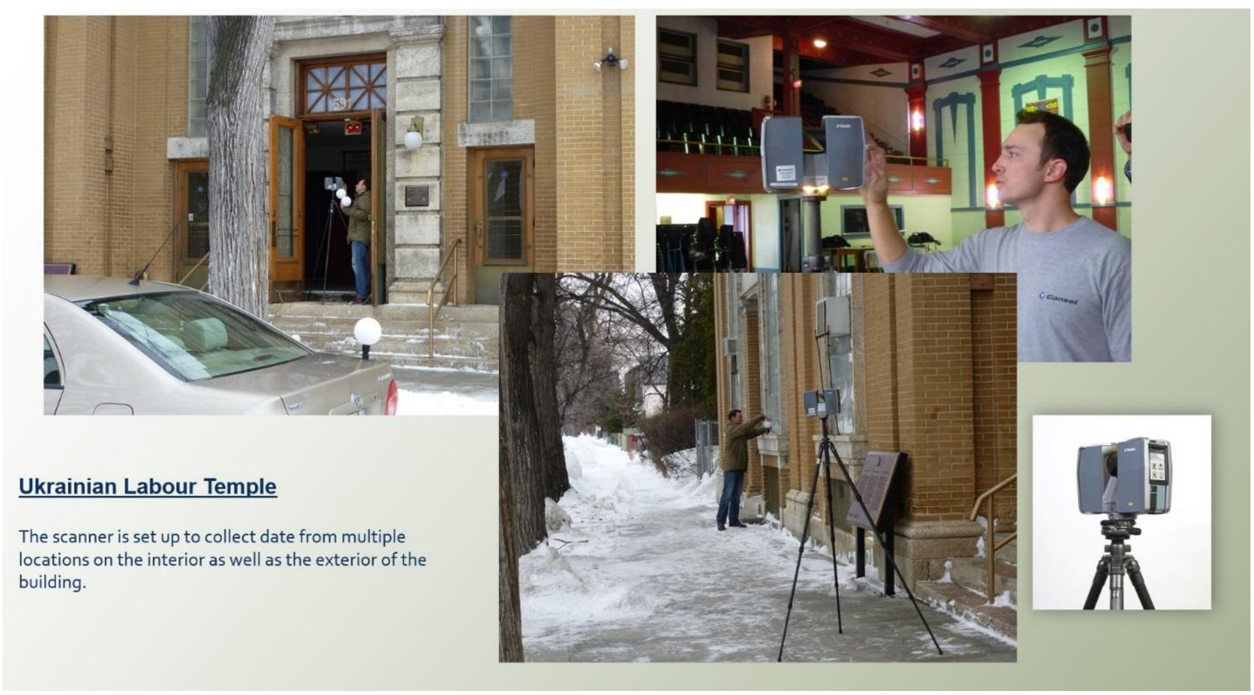


Figure 3: How the scanner is set up to collect data

Discover how to prepare laser scan projects

Process Data

The Data Processing portion of Reality Capture refers to processing acquired data into a useful form. This process is called Registration. During a complete project, the laser scanner is usually placed in multiple positions to get a complete documentation from all sites. Every single scan creates a single 3D point cloud. The next step is to register each individual point cloud. As a result of the registration process, one point cloud data set within one coordinate system is created. Data Processing involves: Registration, Analyze and Measuring, and Exporting

Registration

To register the individual scans together, identical objects in each scan are needed. Depending on the covered object and the needed precision, this is usually done by placed targets. The targets need to be placed on site before the scanning process starts so that they are part of the point cloud.

An alternative to targets is to use natural objects (planes, corners, etc.) within the scan as reference objects for the registration process. *Figure 4 & 5* show different registration options.

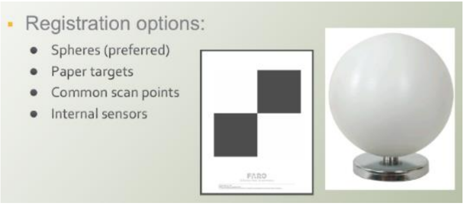


Figure 4: Different registration options

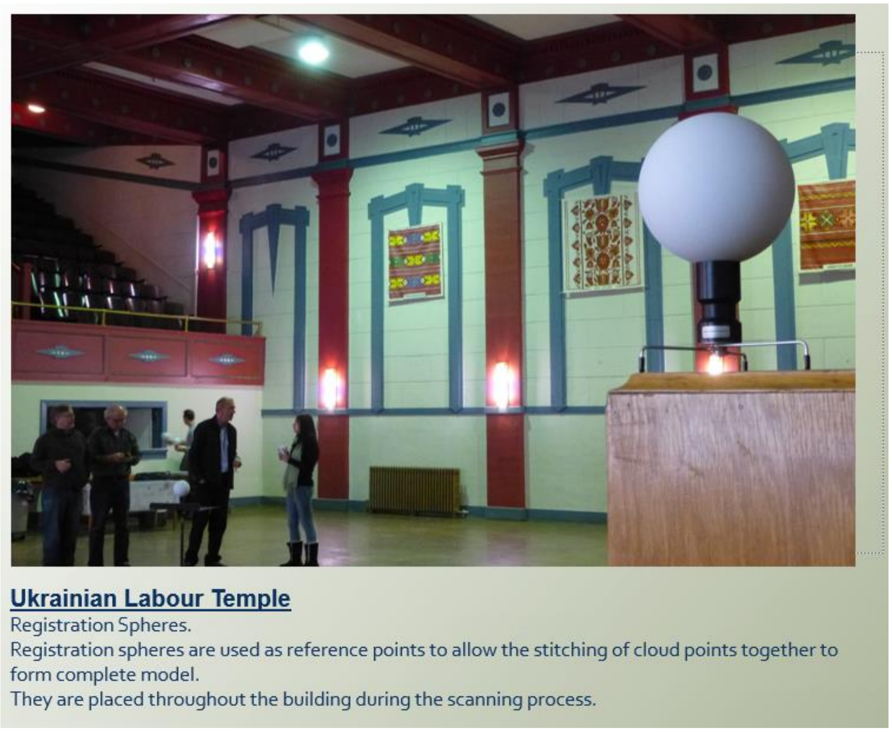


Figure 5: Registration sphere

Analyze and Measuring

This step in data processing is often related to quality control, visual inspection, and 2D & 3D measuring.

Users can select either a single scan, or the entire project to colorize all scans in a single process. SCENE software will automatically equalize differences in the distortion and alignment of the high resolution images captured by the scanner producing excellent results, quickly. The colorization process can also be set as an option for preprocessing all scans. *Figure 5* show the raw data example in grey scale intensity.

This raw data will then go through an automatic colorization of scans

Figure 6: Raw data example

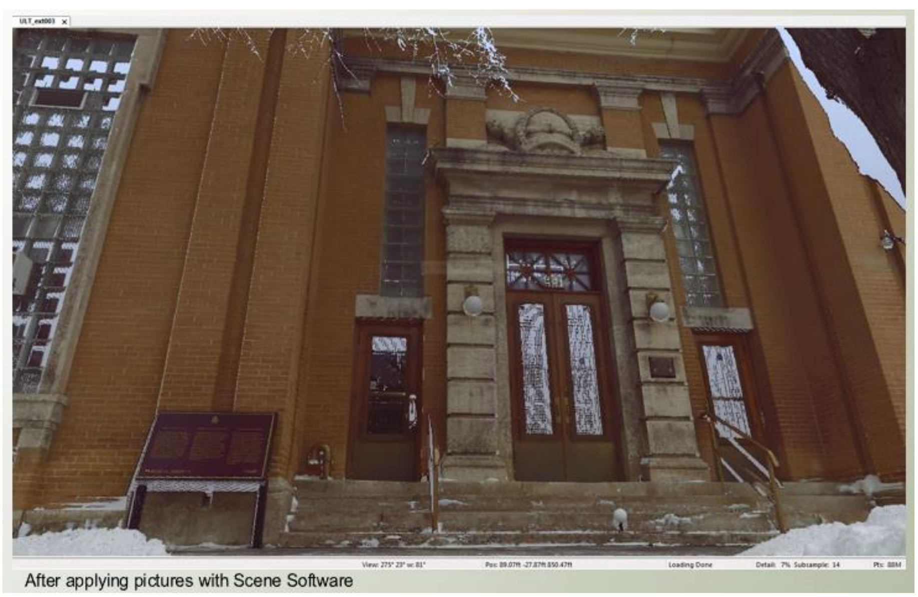
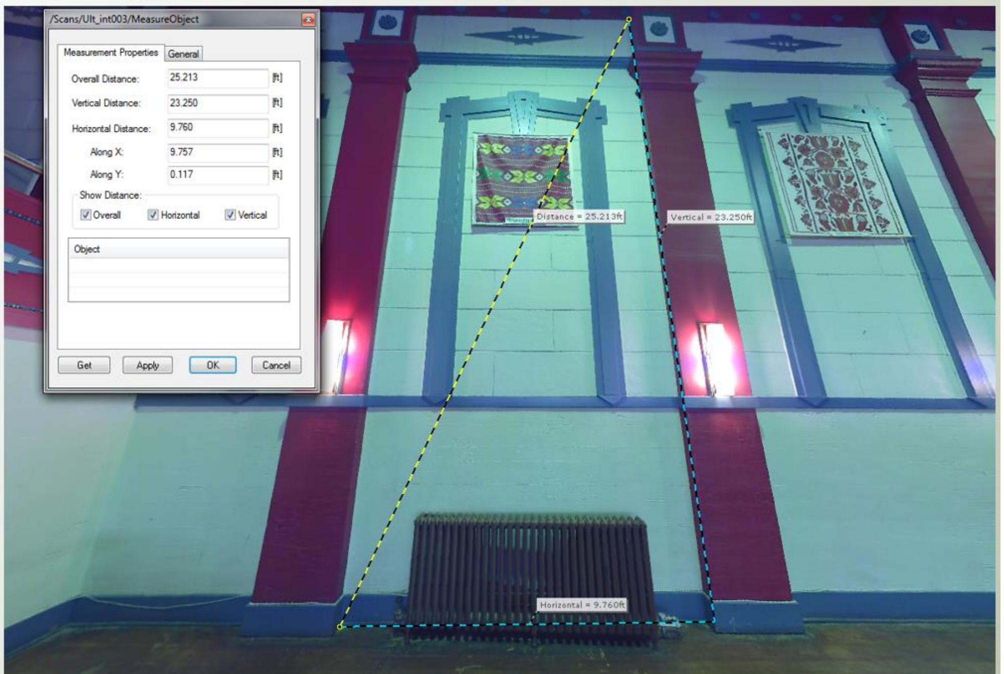


Figure 7: Automatic colorization of scans

SCENE also provides tools to measure between two or more scan points or SCENE objects, in both panoramic and 3D views. Users have the option to display overall, horizontal and vertical distances in any unit of measure, and individual measurements can automatically be retrieved and displayed in the future. Simply select the measurement object from the project workspace and pick Locate. *Figure 8* show the capability of making 3D measurement on any feature.



Capable of making "virtual" 3D Measurements on any feature

Figure 8: SCENE measurement tools

Exporting

From SCENE, scan data can be exported to multiple scan format including Autodesk Recap

- Autodesk ReCap Scans (*.rcs)
- Faro FLS Files (*.fls)
- Faro FWS Files (*.fws)
- Faro Project Files (*.lsproj)
- Leica PTG Files (*.ptg)
- Leica PTS Files (*.pts)
- Leica PTX Files (*.ptx)
- Lidar LAS Files (*.las)
- Zoller&Frohlich ZFS Files (*.zfs)
- Zoller&Frohlich ZFPRJ Files (*.zfprj)
- Ascii ASC Files (*.asc)
- TopCon CL3 Files (*.cl3)
- TopCon CLR Files (*.clr)
- E57 Files (*.e57)
- Riegl Files (*.rds)
- Text Files (*.txt)
- XYZ Files (*.xyz)
- Autodesk ReCap Projects (*.rcp)
- Autodesk Point Cloud (*.pcg)
- Faro XYB Files (*.xyb)

Drafting or Modeling Deliverables

The 1st step for drafting or modeling deliverables is importing data to Autodesk ReCap: Once the data has been registered, users may import the resulting set into Autodesk ReCap. This program accepts scan data from the majority of major scan manufacturers as well as common, open formats, and converts the files into Reality Capture Scans (RCS files). This import process converts each scan position to an RCS file and the project saves as a Reality Capture Project (RCP) which references each RCS scan position. These files are now ready for use throughout all Autodesk design products that support point clouds (AutoCAD, Revit, 3D Studio Max, Navisworks, etc.). *Figure 9* show Autodesk Recap.

The 2nd step is attaching RCP to AutoCAD:

1. Click the INSERT ribbon and choose to ATTACH a point cloud.
2. Select your RCP file and scan data will import to AutoCAD.
3. Click on the point cloud to reveal additional options. Here you will see the list of RCS scan positions which make up your RCP project from Autodesk ReCap.
4. Turn positions on, off or navigate to scan positions freely by double clicking the scan position in the list.

3D point cloud data can now be used as a basis on which to model our Plant objects, as shown in *figure 10*

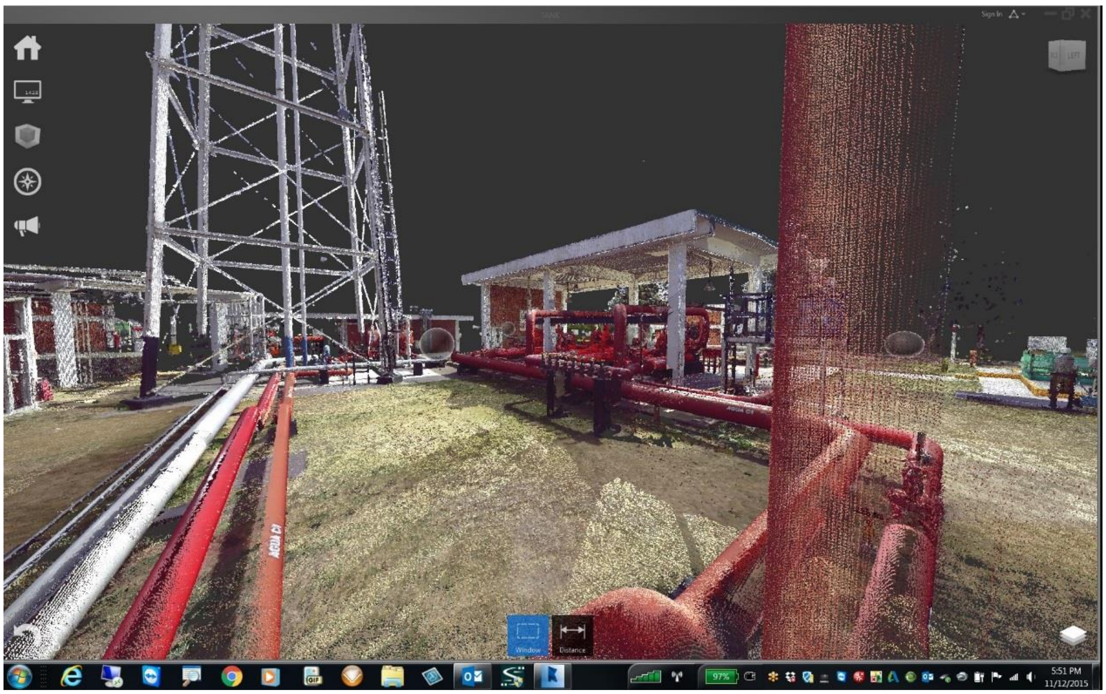


Figure 9: Autodesk Recap

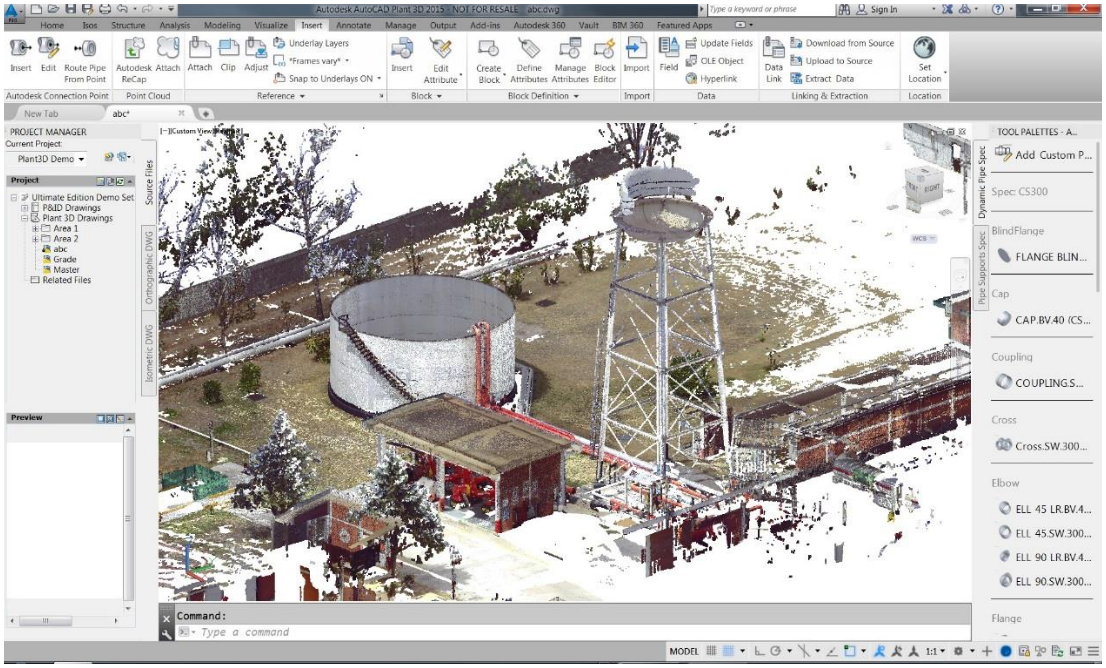


Figure 10: 3D scan data is ready for modeling in Plant 3D

How to extract typically needed plant deliverable from laser scans

The Workflow

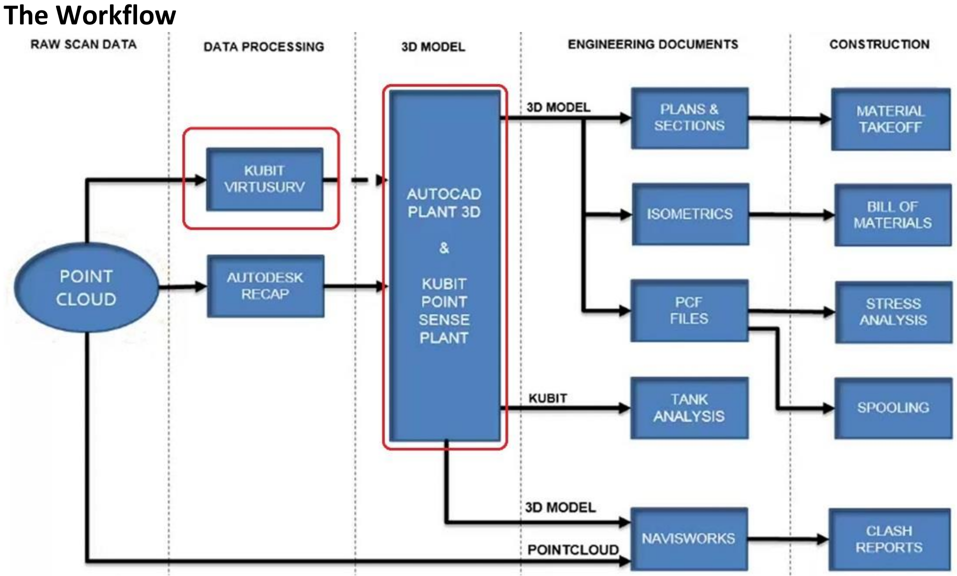


Figure 11: The Workflow

Besides AutoCAD Recap, 3D scan data can also be loaded in Kubit VIRTUSURV. VIRTUSURV comes with FARO PointSense Plant software (Formerly Kubit). Once the 3D scan data loaded in VIRTUSURV, you can use the series of point clouds in a high resolution planar image taken at each scan location.

VIRTUSURV

VIRTUSURV will allow you to transmit points and coordinates from the planar images to any CAD applications. You can also use VIRTUSURV to walk around the scan area to measure objects, and transmit these measurement directly into AutoCAD or Plant 3D for 3D modeling.

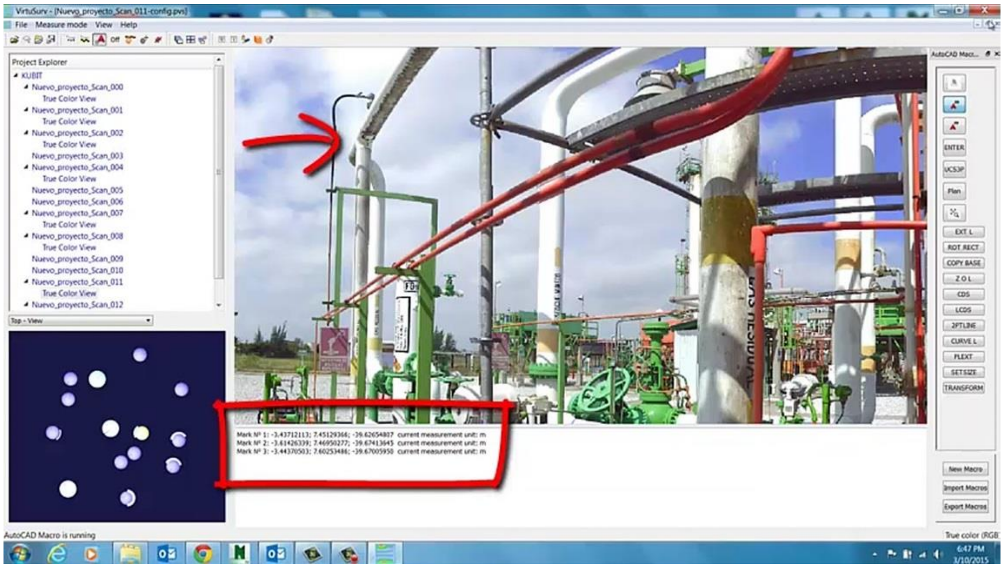


Figure 12: Kubit VIRTUSURV

The Planar Views allow a more intuitive navigation than that in the CAD environment.

FARO Point Sense Plant

Now, you can start to create intelligent 3D models from scan data using AutoCAD Plant 3D and FARO Point Sense Plant.

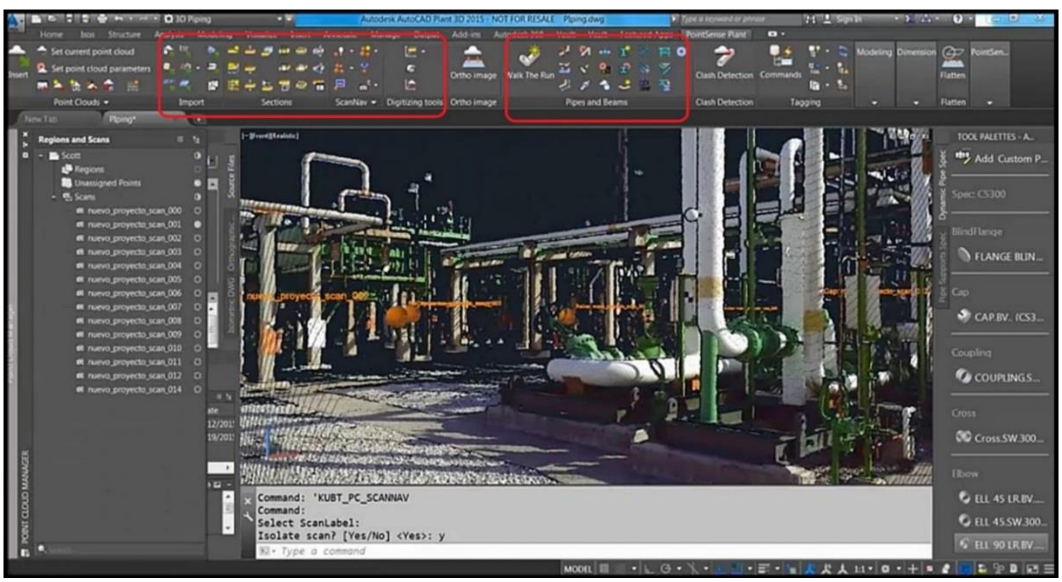


Figure 13: PointScene

Walk The Run – This semi-automated pattern recognition algorithm is the basis for the efficient processing of 3D laser scanner data. Too much automation can lead to expensive mistakes. As the

"Walk the Run" function guides the user through the pipe system, the pattern recognition, on the basis of a catalogue, suggests types and positions for recognized pipes, bends, tee pieces and fittings. These procedures give the user full control over the modeling process, and ensures geometrical and technical workmanship. The thickness of the insulation is taken into account in pattern recognition.

Apply Constraints –The way to compatible models Plant design software requires coaxial centerlines for fittings and pipe bends that must be coplanar. The function "Apply Constraints" creates pipe runs that on the one hand fits the point cloud, and on the other hand, satisfies the consistency conditions of the plant design software. In the same way, steel construction elements are aligned coplanar to each other, and if need, to be perpendicular, and trimmed.

KPM (Kubit Plant Module) - FARO 3D Software provides a standard catalogue of fittings. Plant 3D catalogs can be directly imported. In cases where the fittings are missing or special fittings (out of spec) are needed, the user can create his own fittings or even full catalogs. The software then uses them in the pattern recognition process.

Tie-Points - Pointsense can be used to determine precise tie-points, if required. They can be surveyed and marked, with little or no modelling required.

Export – Once a piping run has been modeled, we can export pipe centerlines and fitting information. The Pointsense solids can be converted to AutoCAD Plant 3D objects, 3D solids or a labeled centerline layout. The standard AutoCAD objects can be used afterwards in any plant software systems. The same model and export process applies to steel construction.

Tank Analysis - Pointsense can be used to analyze cylinders and truncated cones. Tanks, boilers or containers can be unrolled and checked for deformations. It is possible to precisely compute volumes including taking the internal subtracted volume (deadwood) into account. Cylinders, elliptical and circular truncated cones are all supported.

User experiences regarding converting point cloud

Demonstration Scopes
Through a series of 4 demos, Irene will share with us how to incorporate scan data into a number of typical engineering workflows.

<u>1st Demo</u>:

In the 1st demo, Irene will take us through the process of using scan data to bring 100% accurate field conditions into our desktop environment in order to design and validate the location of our new scope. By modeling directly inside the point cloud, we can locate new equipment, identify tie-point locations, and validate the location of the new piping. The steps are outlined below:

- Register scan positions within Faro's Scene software
- Using Autodesk Recap, index scan files to export to Plant 3D
- Import to Kubit's VirtuSurv product to enhance viewing quality of scan data
- Begin identifying and extracting tie-in points via PointSense Plant
- Model new pipe runs based on existing conditions
- Extract Isometric drawings to be issued for fabrication
- Use Navisworks Manage to check for interferences to ensure that new scope fits into the existing plant conditions.

Let's take a look at the field to finish workflow that allow you to take an intelligent 3D piping model from a 3D scan data.

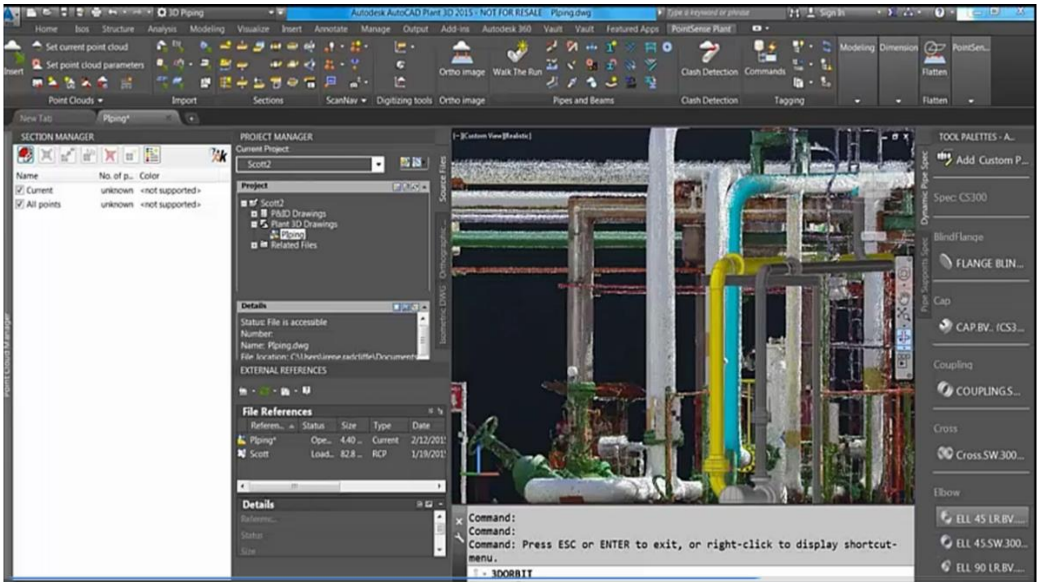


Figure 14: 1st Demo

<u>2nd Demo:</u>

In the 2nd demo, Irene will show us how use FARO Pointsense Plant to execute tank deformation analysis using 3D laser scans. There are the steps taken during the demo:

- Isolate the points on the circumference of the tank
- Clean up defects or "noise" which may return false values in the analysis.
- Run the analysis using Kubit fit cylinder

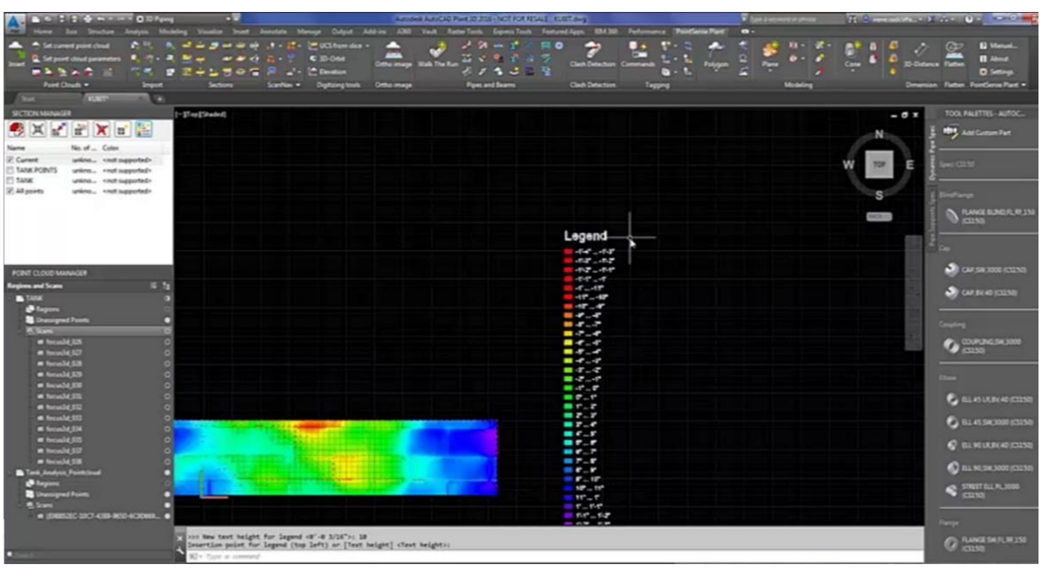


Figure 15: 2nd Demo

3rd Demo:

In the 3rd demo, Irene will show the process that involved in locating center of flange from 3D laser scan. There are the steps taken during the demo:

- Clip the point cloud to isolate the run that is to be used.
- Eliminate background noise in 3d scan data.
- 1st method of modeling flange from point cloud using VirtuSurv.
- 2nd method of modeling flange directly in the point cloud.

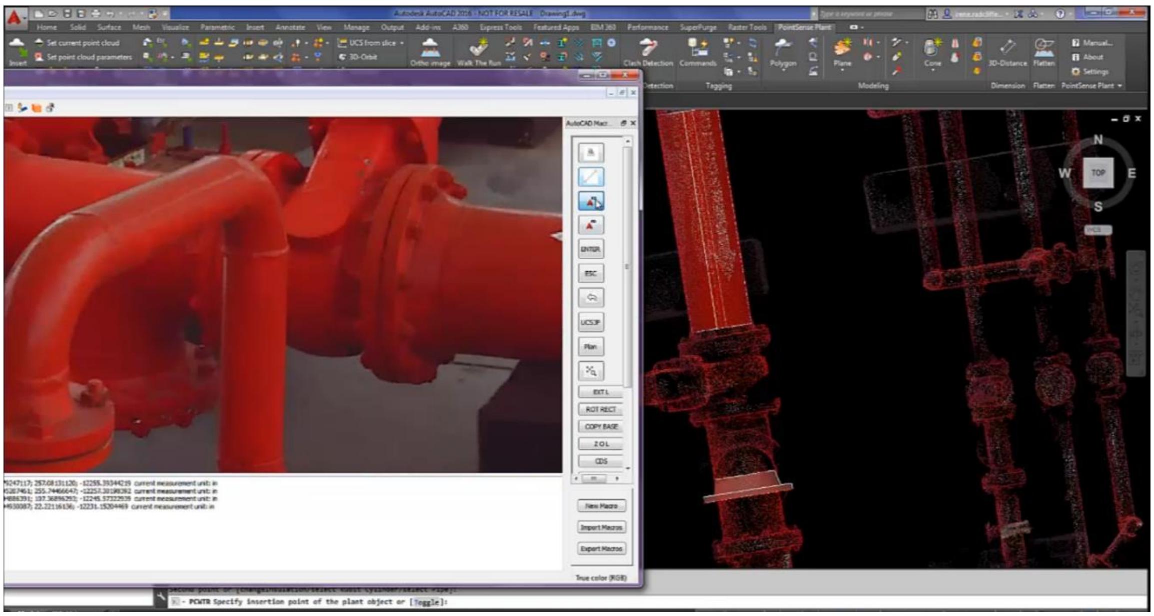


Figure 16: 3rd Demo

4th Demo

In the 4th demo, Hung and Irene will show the complete process of registering raw 3D scan data. Taking the data from the FARO scanner using SCENE, exporting scan data from SCENE to Autodesk Recap, and importing from ReCap into Advance Steel to create new railing construction from a 3D laser scan. These are the steps taken during the demo:

- Introduction to SCENE
- Register raw scan data with SCENE
- Processing and colorizing raw data
- Importing registered scan data to Autodesk Recap
- Importing point cloud to Advance Steel with PointSense
- Using PointSense to clean up point cloud
- Creating railing with Advance Steel

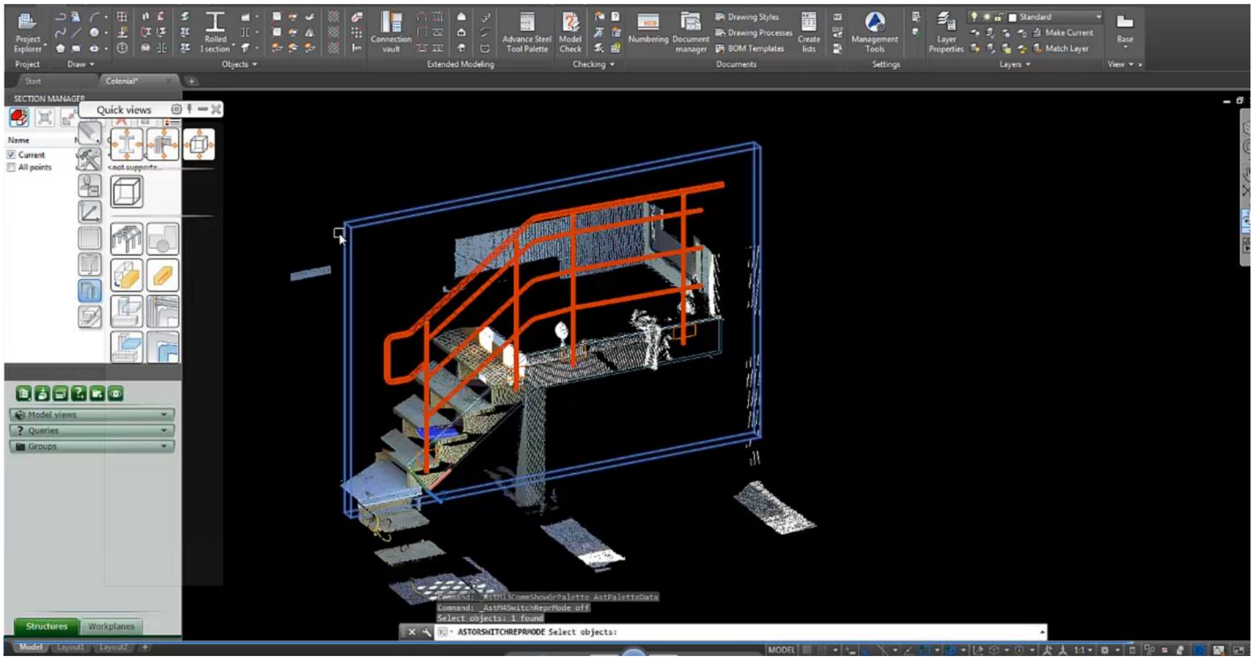


Figure 17: 4th Demo

Conclusions

Through this series of 4 demonstration, we've shown you how Laser scanning and point clouds are becoming essential tools in the engineering/design/construction workflow.

By taking you through the process from laser scans to desktop engineering design software, we hope to have highlighted some ways that laser scanning can greatly improve your current workflows. By improving accuracy of field measurements, providing safer way to take field measurements, and allowing you to validate new scope by designing directly inside the point cloud, you can now extract and create accurate as-built and new construction deliverables with confidence.

Thank you,

Irene Radcliffe & Hung Nguyen