ES124403

3D Laser Scanning and Revit Design Workflow

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Learning Objectives

- Learn how to successfully import scan data into Revit and align it for use
- Learn how to successfully manipulate the view of the scan data with clipping boxes, sections, and view ranges to better visualize the data.
- Learn how to successfully model in architectural and structural elements with the use of scan data as a reference.
- Learn how to successfully model in mechanical equipment and pipes with the use of scan data as a reference.

Description

We will cover the concept of 3D laser scanning and how to take it from a raw scan—a quick overview of processing to modeling of architectural, structural, and mechanical systems. The main portion of the class will be the import and the use of the 3D point cloud data in Revit software. Topics will be how to orient the data for use and how to work with the point cloud data visually, as well as the use of clipping boxes, section cuts, and view ranges to declutter and clearly see the point cloud data. We will show how to model walls and structure and also how to model in piping and mechanical equipment. Finally, we will cover a case study of how 3D scanning and using the data with Revit saves us time and money—and also helps us deliver a product that is accurate and greatly reduces the chances for addendum and change orders in a project.

Speaker

Lead Technician and Designer for the Water and Wastewater Group with over 17 years of experience. Also the primary 3D laser scanning technician at SEH. Primary duties are the design of water/wastewater facilities using AutoCAD and Revit. 3d scanning is an integral part of our work flow here at SEH and I incorporate that on most projects. Education is an Associate degree from Chippewa Valley Technical College and a Bachelor degree in Computer Science from Lakeland College. I also sit on an advisory committee for over 6 years for the Architectural and Engineering Technician program at Chippewa Valley Technical College.

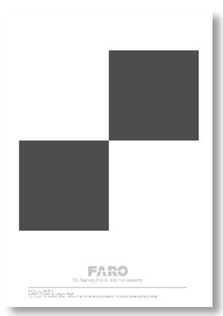
What is 3d Laser scanning?

3D scanning is the process of capturing three dimensional spatial information about objects in range of the laser scanner. Most laser scanners will gather this information is a near spherical sightline from the scanner. It works by measuring changes in the properties of the reflected laser off an object. This could be “time of flight” or “phase shift” or both. Time of flight measures the time it takes the laser to be sent, and return from an object. It then uses the speed of light in a calculation to determine the distance. The phase shift scanner uses a continuous beam and measures the properties of the phase of the return to determine distance. The laser scanner I use will return data from as little as a fraction of a meter away up to about 330 meters. As long as the scanner can “see” an object, it will scan that object. There are a few exceptions that we will discuss. Each and every one of the millions of points that make up a laser scan will have an X, Y, and Z coordinate assigned to them and either a reflectance intensity value or a color. The color does not come from the laser, but rather it comes from a photo taken during the scan were the color from the photo is mapped onto each point.

Key terms in Laser Scanning

Laser Scanner - The device that both sends out the laser and receives and records the return signals.

Targets - Objects that are placed within the scan to aid in scan registration.



Checkerboard Target

Registration - The act of aligning multiple scans using common targets, or the scan area itself.

Point Cloud - The millions of points in three dimensional space that are derived from one scan or multiple registered scans.

Intensity vs. Color - A scan will naturally be in “black and white” or intensity, but it can be colorized.

Planning a laser scan

Whether you will doing the scan or you will be providing the scanning professional information to do the scan there are several factors to consider.

Estimated Time to scan?

This is my most common question and the answer is…. It depends.
Scanning time is mostly a function of the number of scans or setups required. The square foot size of an area is not usually the best determination of how long it will take. While that is certainly a factor, the complexity along with the sized is a much better determination. Think of scanning the interior of an empty warehouse. Just a few scans will pretty much cover the entire four walls, ceiling and floor. Compare that to a small library. From any given point in the library most of the rest of it is obscured by book shelves. Many setups will be needed to cover a much smaller area effectively. This holds true with an area with complex machinery and pipe runs. Bottom line, there is no exact way to plan for scanning time. This will come with experience. The more information about the area to be scanned going in will be helpful on planning.

Requirements of the scan.

Ultimately, what the end use of the scan is, will be the largest factor in to how it is scanned. Some questions that need to be answered are:

- What does the scope of the scan include? Interior, exterior, roof, ceiling space, in every room and closet, behind every piece of equipment, etc.
- Is color needed? Is sufficient light available for a color scan?
- Are the places to be scanned safe for both the operator and scanner? Is special safety training or PPE required?
- Can the interior be cleaned up to help with the aesthetics of the scan? If the exterior is going to be scanned, a freshly mowed lawn will help with a more accurate ground topo if that is important.
- Can the staff be notified of the scanning that will be going on so they can be out of the area as much as practical?

With these questions answered, the data can be gathered in the most efficient way possible.

There is always a balance between too much vs. too little. For example, in a given area, three scans may scan 80% of all object possible. By adding in a fourth scan, you bring that up to 85%. Subsequent scans may just get you a small percentage more and you have to ask yourself, are they worth the time? That is a question you will have to answer on a case by case basis. Take an office for example. A wall behind the desk may be hidden, but for most cases it is safe to assume that the floor meets the wall at a 90° angle and there are no surprises. That may not be the case in a boiler room where the boiler obscures some mechanical piping. When scanning, the scanning technician is always performing a cost benefit analysis to provide enough but not too much to blow a budget.

Importing scan data into Revit

In this section we will go ove the types of scan data files that Revit uses, how the import it into a Revit model, and how to align them in all three axis and rotationally.

File types for use in Revit

Revit is looking for either an .rcp, or a .rcs file.

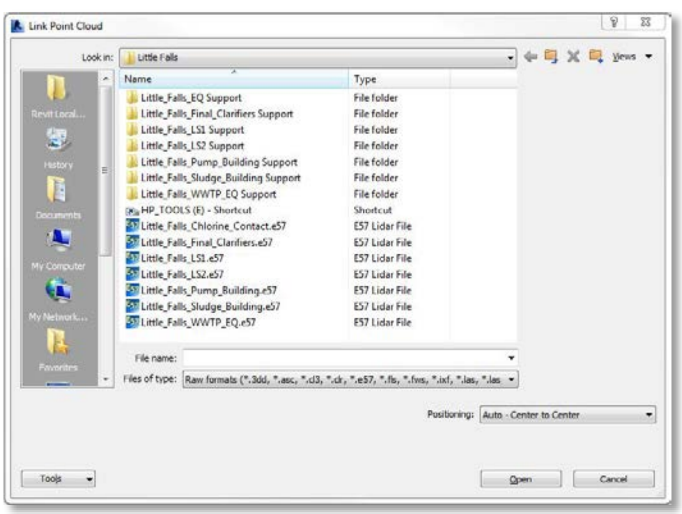
- An .rcs file is a scan file with the actual data for all the points. This is a large file.
- An .rcp file is a scan project file that contains the information on now one or many .rcs files relate to one another. If an .rcp file is used, its companion .rcs files need to stay with it in the same manner as they were created.

Revit can also import many different raw scan files. Although it can do this, it does not use them directly but create a .rcp/.rcs set of files to import.

To import a raw scan file, follow these steps.

There are many types of raw scan file types such as .fls, .fws, .las, or .e57. I am going to focus on the .e57 file typ for this discussion.

1. With a new or existing Revit drawing open, click **Point Cloud** on the *Insert Tab* and it will open up the *Link Point Cloud* dialog box.
2. Change the *Files of Type* box to "Raw" formats and find the appropriate .e57 file. In this case I will be doing the Little_Falls_LS2.e57 file.

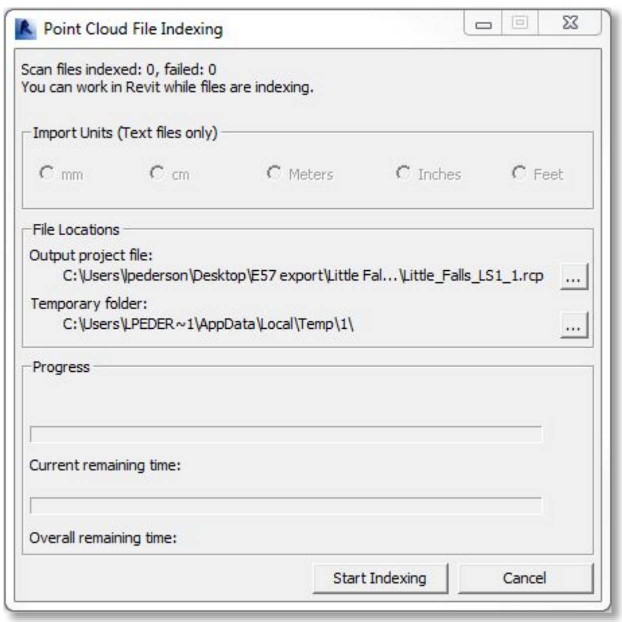


3. Select the .e57 file and click **open**.

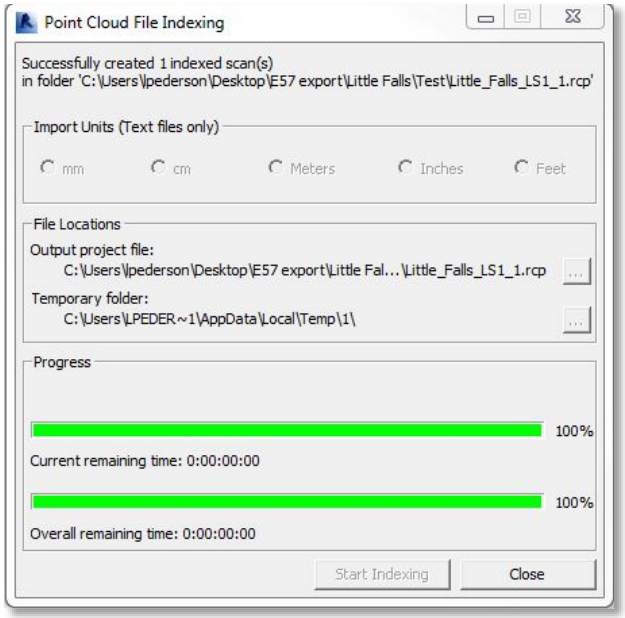
4. Revit will now let you know that the file you selected is not indexed and will give you the opportunity to index it. If you select no at this point, nothing will be done. In order to proceed you have to select yes. The raw file you are importing contains all the data, but it is not usable by Revit. Revit must index it in a way that it can use it. Select **yes** to continue, but not the warning at the bottom of this

dialog box. The time it will take to index is directly proportional to the size of the raw file, which in turn is proportional to the number and size of the scans it contains. Also, computer performance is a factor in the time. Although indexing can take some time, it can be done in the background.

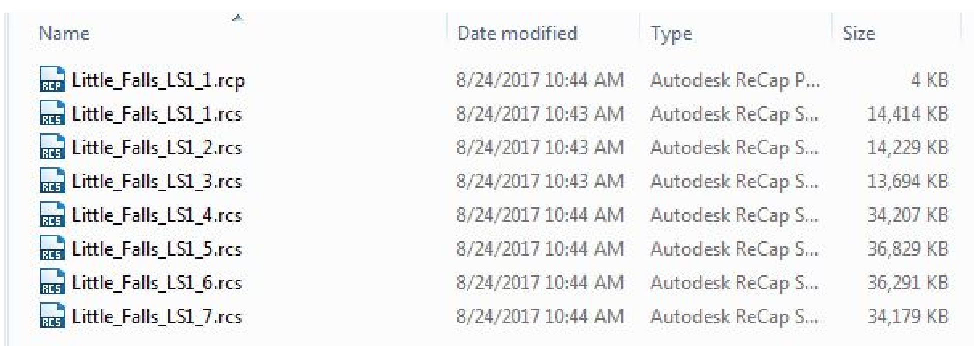
5. Once you click yes to this you will be given the opportunity to tell Revit where to save the .rcp/.rcs files it will create. Choose the location for the output files and click the **Start Indexing** button.



6. Once the indexing process has been started, you have the option to close this dialog box and continue with other work within Revit if you choose to. If you choose to leave the dialog box open you can see the progress in the progress bars. Again, this can take some time, so the choice is yours.



7. In the above image, I left open the dialog box so you can see the completed progress. The next part is a bit counter intuitive. Once you click close, Revit returns to wherever you left off with no indication that you were trying to insert a point cloud. Even though we started this off by inserting a point cloud, really what we did was create some indexed files to insert.

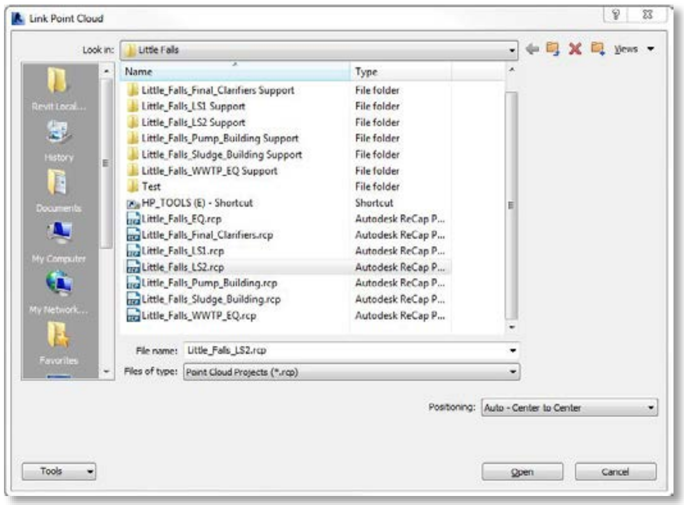


8. The indexed files where created in the directory you specified earlier. We must now start the command again to insert these files. To do this, follow the steps below for inserting indexed scan files.

Importing RCP/RCS Files

To import indexed .rcp/.rcs files or single .rcs files, follow these steps.

1. With a new or existing Revit drawing open, click **Point Cloud** on the *Insert Tab* and it will open up the *Link Point Cloud* dialog box.
2. Change the file type to either .rcp to insert an indexed group of .rcs files, or .rcs to insert a single .rcs file.



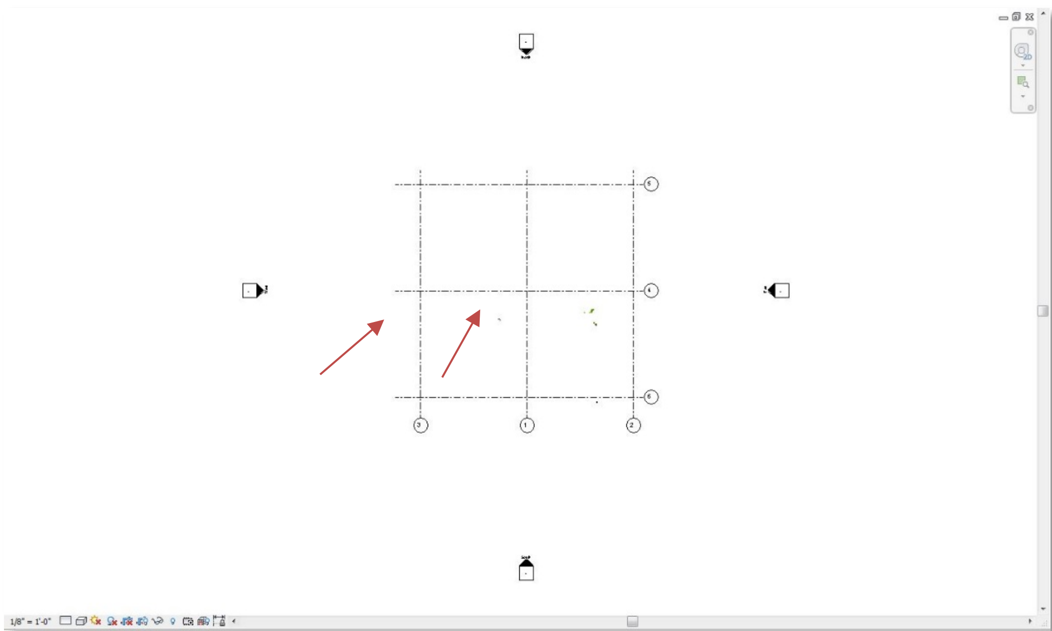
3. Select the file you would like to insert, in this case the Little_Falls_LS2.rcp. Before clicking open you have three options as to how to position your inserted file. Center to Center, Origin to Origin, or By Shared Coordinates.
4. Center To Center puts the center of the point cloud in the center of the level you have active in Revit.
5. Origin to Origin, will match up the zero coordinates of the point cloud to the zero coordinates of the Revit model.
6. By Shared Coordinates will alight the coordinate systems of both the Revit model and the point cloud.
7. For this demonstration we will be selection **Center to Center**. Click **Open** to insert the point cloud.
8. At this point the point cloud is inserted into the model with its three dimensional center placed at the two dimensional center of the level to which it was inserted.

Helpful tip regarding the .rcp/rcs files: Keep them stored on your local hard drive. These files can be very large and loading them over a network can take quite a bit of time when opening a Revit model. If you keep the folder structure the same on your C drive as others in your company, the reference path will be the same no matter where you are and there should not be the problem of broken paths for referenced point clouds.

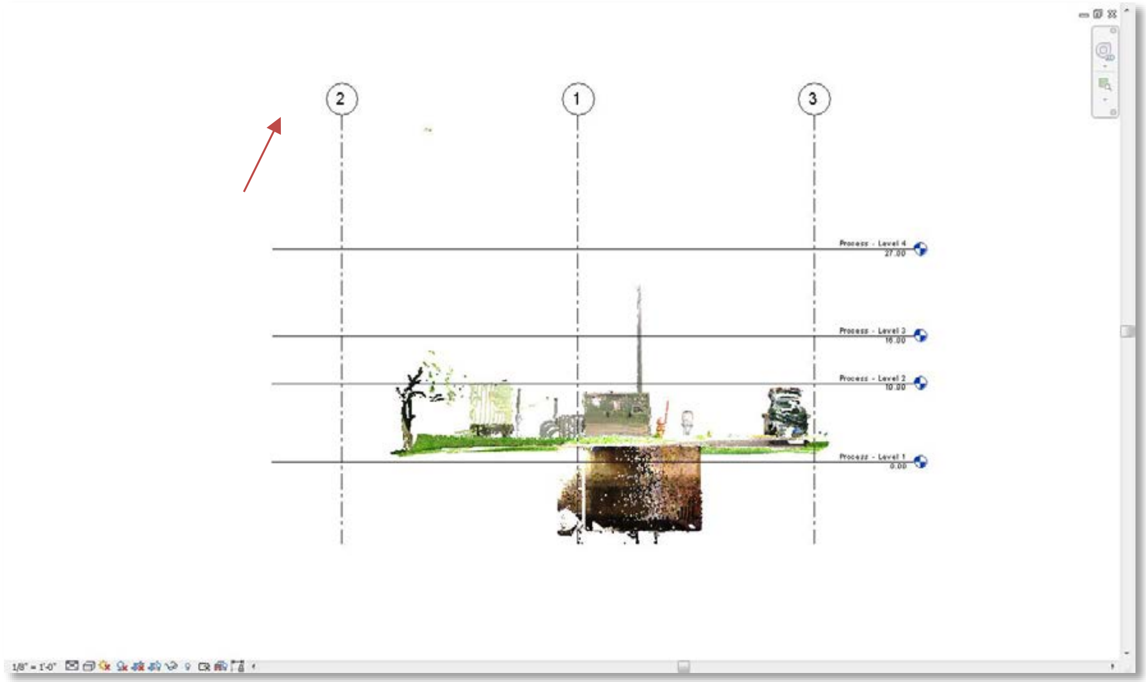
Aligning the point cloud.

The point cloud is now referenced into the model. It will most likely need to be aligned both vertically and horizontally to make modeling easier.

Aligning the point cloud vertically.



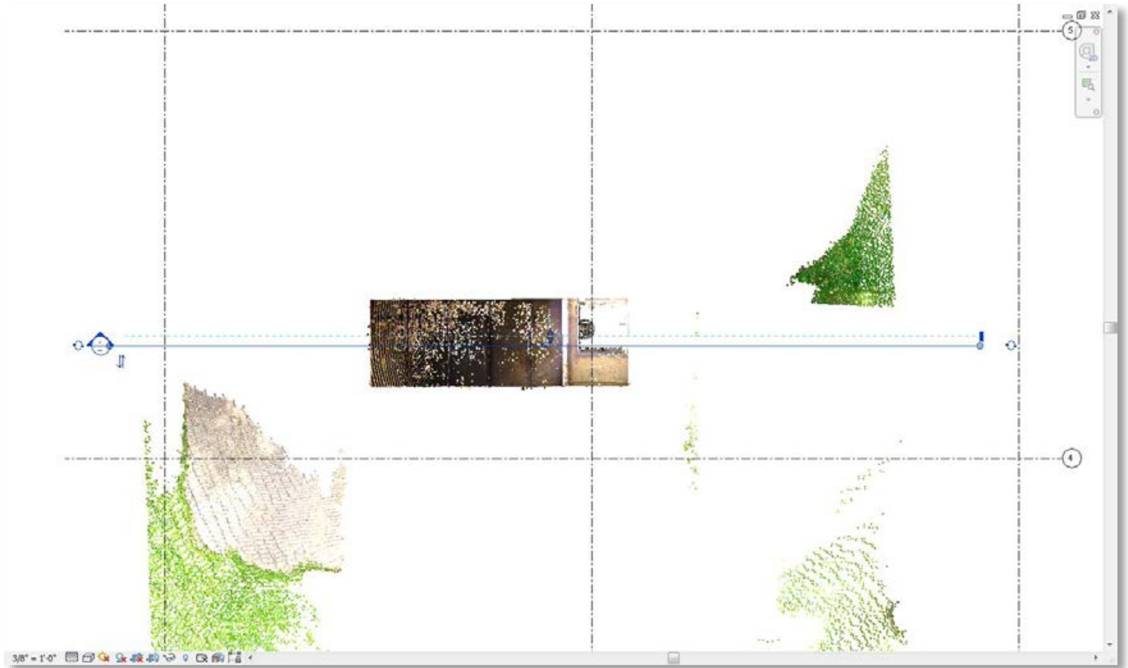
Notice there appears to be a point cloud inserted, but something is just not quite right. Only what appears to be a small portion of the point cloud is visible. This is because this particular point cloud has a large area of dead space above where most of the data is. This causes the vertical center of the point cloud to be artificially high. Since Center to Center was used to initially position this, most of the point could is well below the visibility limits of this particular level. See an elevation view in the next figure.



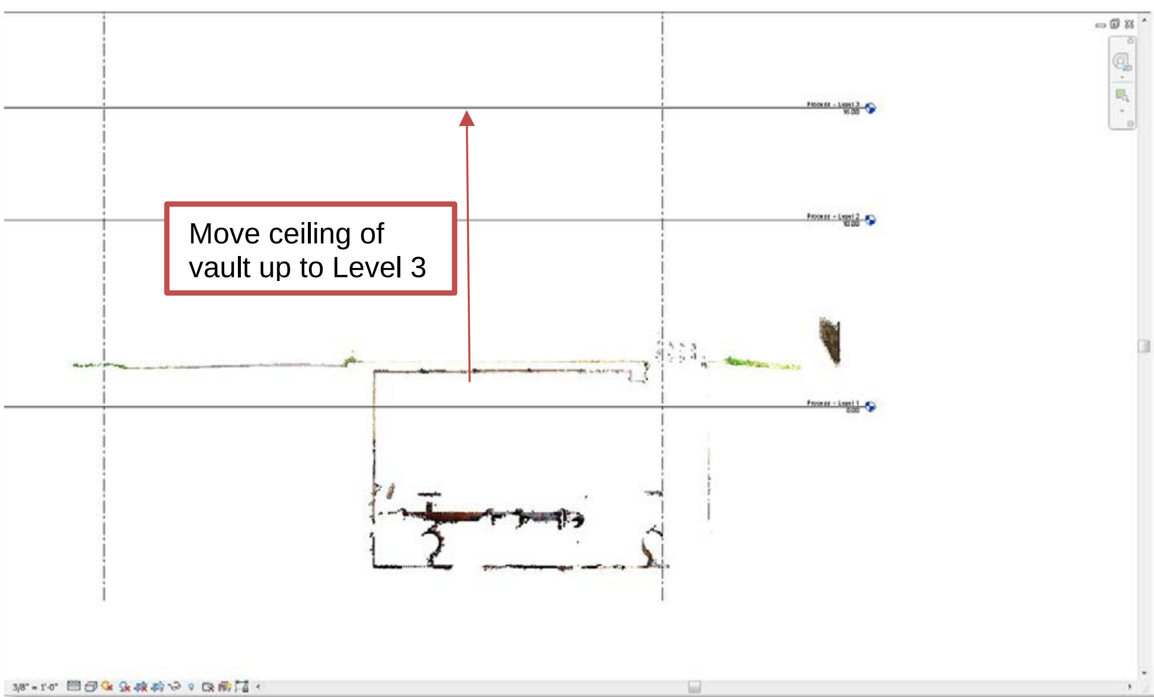
The small part of the point cloud in the upper left in this elevation view is that is throwing the location of this point cloud artificially low relative to Level 3, where it was inserted. The point cloud could be cleaned up a bit to make it work better, but at this point it is easier to just deal with it like this.

What needs to be done first is to establish where to move the point cloud vertically. Most cases a floor level will be established in the point cloud and the point cloud moved vertically to match that floor level with the appropriate level in Revit.

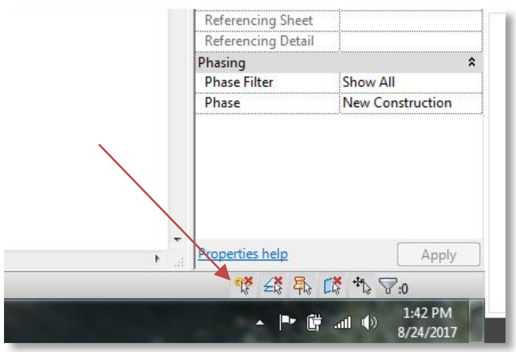
This is done in an elevation view, or better in a section view. We must first create a section view that will allow us to do this. It looks like Level 1 will be a good place to draw a section. Go to Level 1 and draw that section.

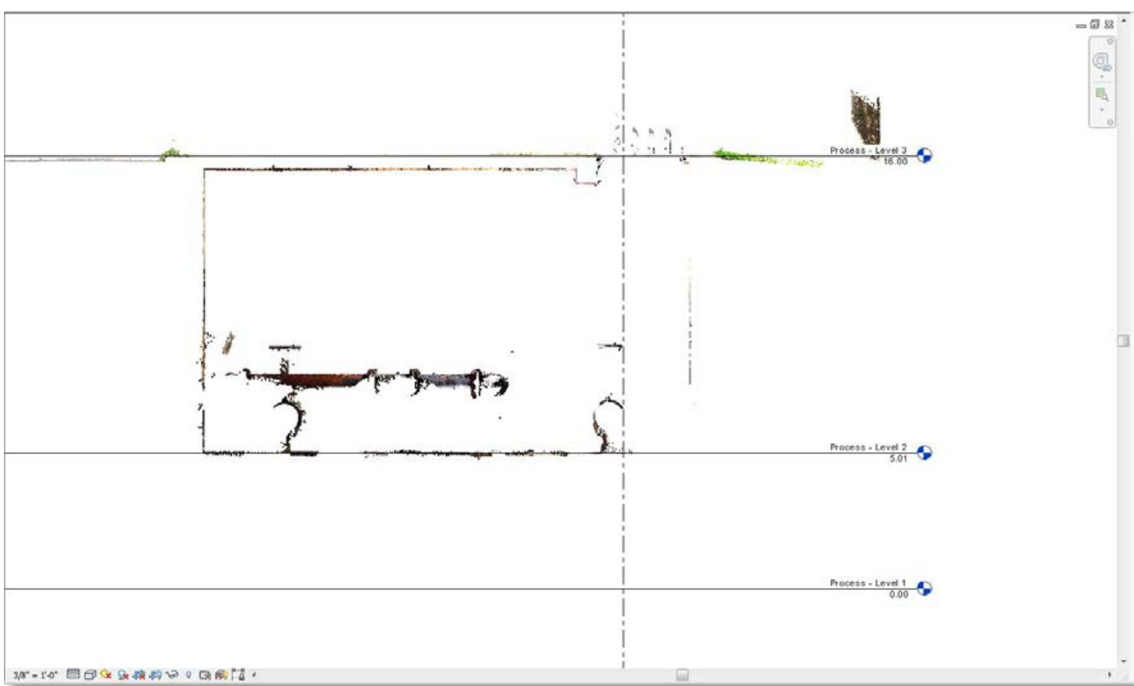


Here the section has been drawn on Level 1. Notice how I drew the section through the structure but set its view range very shallow. This will allow you to see a very thin section of the structure that clearly shows the roof and ceiling planes of the structure. In this case we are looking at a buried valve vault.



In this thin section view you can now clearly see the point cloud levels that will be used to align to the Revit levels. In this case there is really just two levels that I need. One at the top of the vault, and one at the bottom of the vault. When I was there scanning this I remember there was one other level down below the floor that could not be picked up by the scanner. There is nothing above the roof of the vault though. Given this information I will align the top of the vault with Level 3 leaving levels 2 and 1 below it to be dealt with later. In Revit, point clouds are able to be snapped to. If you find yourself not able to click on your point cloud then likely your Activate Links option is turned off. This is a feature that I turn on and off quite a bit. I have it on when I need to manipulate point clouds and other linked files. The down side is that when it is on, every time you hover over a linked file, it activates and changes color. So when I just need to see linked files but not interact with them, I turn it off so they are just there visually in the background. To toggle the Activate Linked Files click the little gold chain link in the lower right of your Revit window.





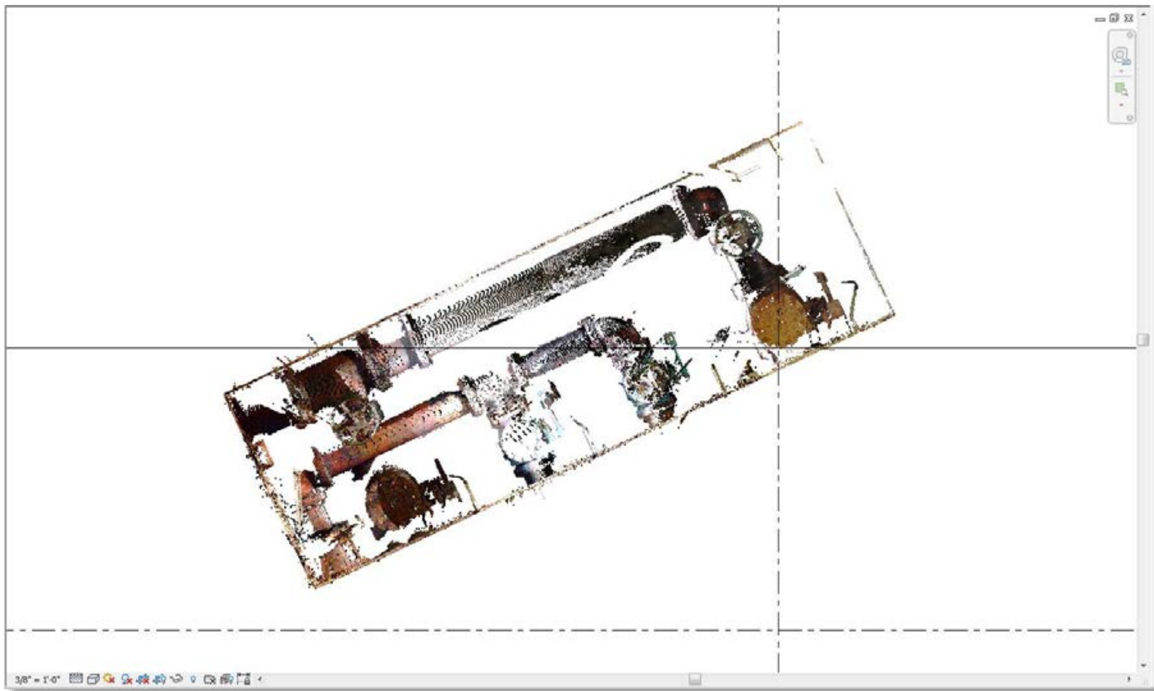
Now you will see section 1 is aligned vertically to Level 3. I also took Level 2 and aligned it with the lower level of the vault. Again, I do know that there is one more level below that is not visible, so I will save Level 1 for that later. You will notice that the point I picked to align Level 2 within the point cloud is very close to 5.00' or 11' below Level 3. This is the point where you will have to make some judgement calls. I will assume that the vault is 11' deep and to normalize my dimensions for future modeling, I will adjust Level 2 elevation to be exactly 5.00 instead of 5.01. You will also run into some decision like this when determining where to pick in the point cloud to establish your levels. Uneven or sloped floors will present some challenges. There is no right answer and will require some judgement on your part.

Next, is to move the entire model either up or down depending on where you want your model to be in vertical space. For this example we want the top of the vault or Level 3 to be at elevation 655.00. To do this click the **Manage** tab, then the arrow below the **Position** button. Then click relocate project. Since we are in a section view I can the model up, down, left or right. I want to move the model up 639' (655'-16' = 639'). Once that is done the model is moved to the correct elevation that I need for this project and the levels are aligned properly relative to the point cloud.

You can now see in the above example, the point cloud is aligned to the levels, the level elevations are normalized and the level elevations are adjusted to this project specific elevations.

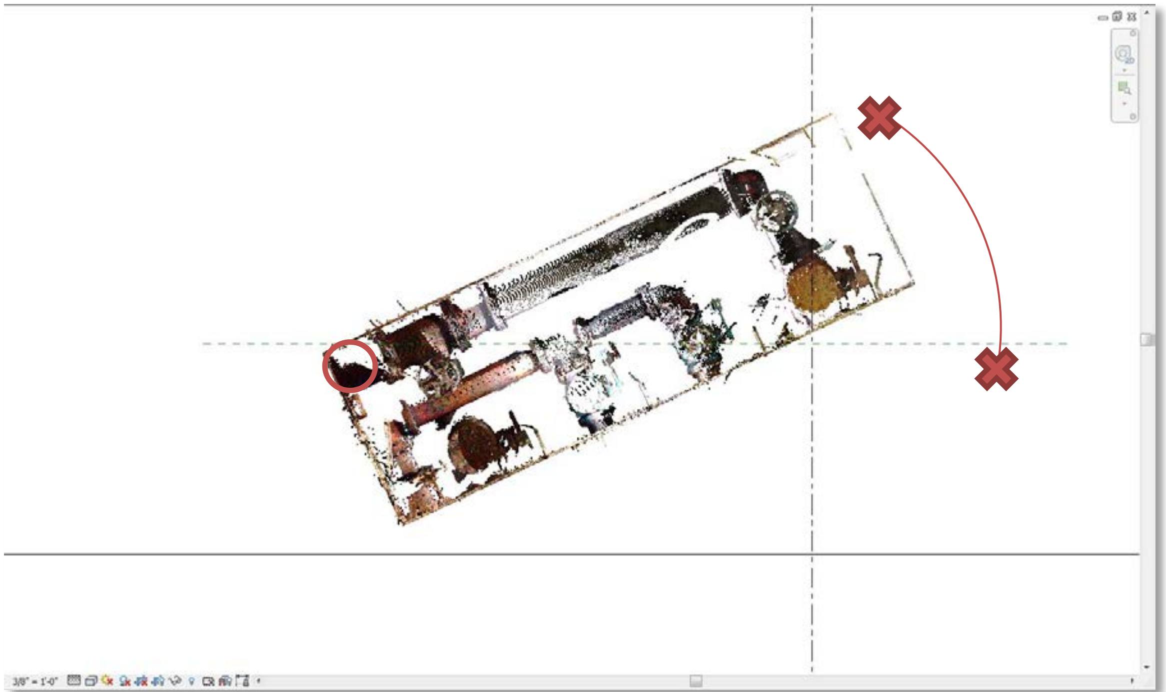
Aligning the point cloud horizontally.

In some cases the point cloud may sit skewed within the model. This may be just how it was scanned or maybe the structure does not sit true square with north and south. It is much easier to model from a point cloud if the point cloud is sitting square on your screen. With more complex structures where many walls do not sit at right angles to one another you may have to use your judgement on how to position the point cloud in plan view.

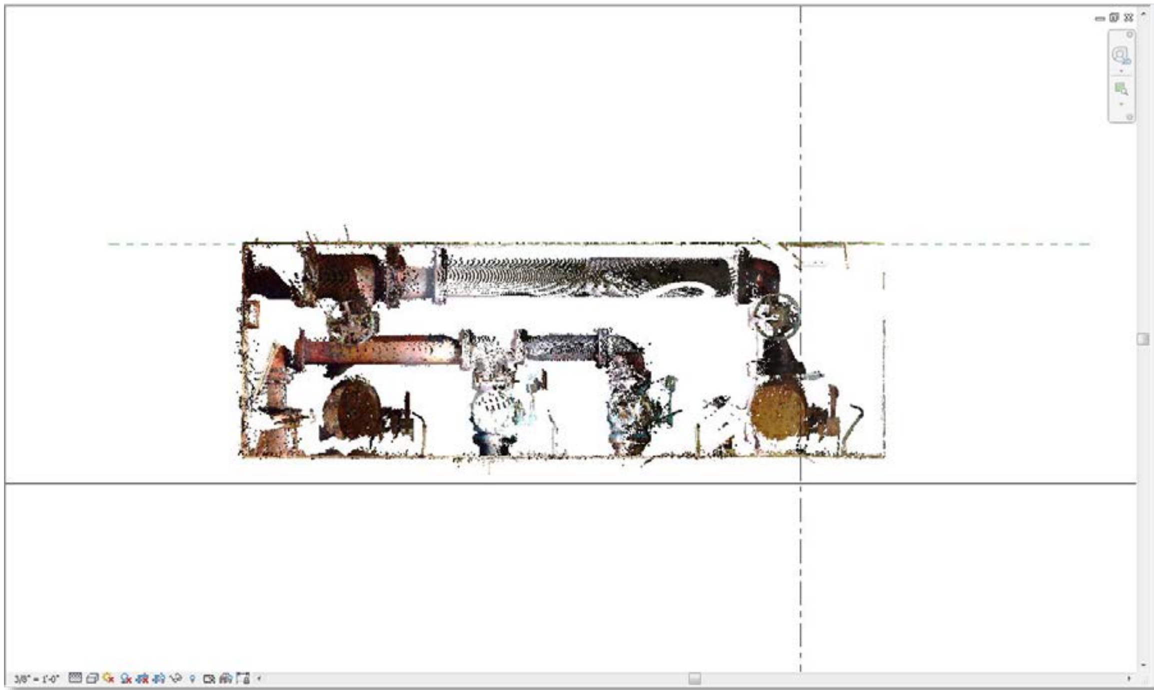


I have used the previous vault point cloud as an example. This point cloud was processed so that it would import nice and square, but not all point clouds are like that. I have rotated the vault in this example not to show how to square it up if need be.

Autodesk University



The process is simply to draw a reference plane in your model to use for alignment. Remember in order to manipulate the point cloud, the Select Links option has to be toggled so that the point cloud can be activated. Then move one point on a wall you want to align so that it touches the reference plane. Now rotate the point cloud with the base point of rotation at the point where the wall and the reference plane intersect. Pick a point far away from the point of rotation on the wall and rotate it down to the reference plane.



Now the point cloud is aligned so that it can be more easily modeled with walls in the X and Y planes. Obviously this is a very simplistic example. How exactly you choose to align your point cloud both vertically and horizontally is specific to the project you are working on. The concept and the methods are still the same though.

One other tip is the order that your do your alignment vertically and horizontally is up to you. There may be reasons to choose one first vs. the other. That is up to you.

At this point we have learned about raw and indexed scans and how to import these files into a Revit model. We have also learned how to align point cloud both vertically and horizontally. We are now set to begin modeling the project using the imported and aligned point cloud as a reference.

Improving the Visibility of the Point Cloud.

Learn how to successfully manipulate the view of the scan data with clipping boxes, sections, and view ranges to better visualize the data.

View range adjustments to best view the point cloud for modeling.

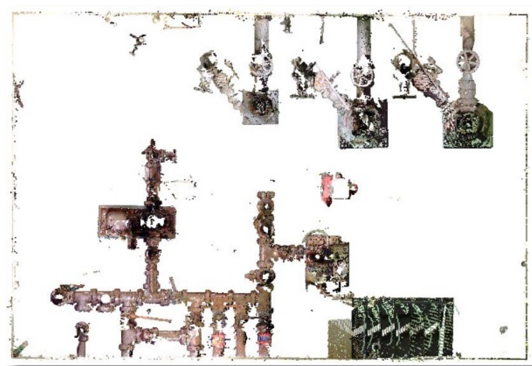
For this part I will be switching to a more complex example. This example is a small building with a lot of pipe and equipment within it to model. The building is a one story precast building with two floors below grade. The building was constructed in the mid 50's. We do have original construction documents, but it is well known that over the last 60 years many modifications were made to both the building and the equipment within.

Once the building has been imported, oriented horizontally, aligned vertically, and the levels created and adjusted, the next step is to create and adjust views to be able to efficiently model the structure and equipment.

Adjusting view range

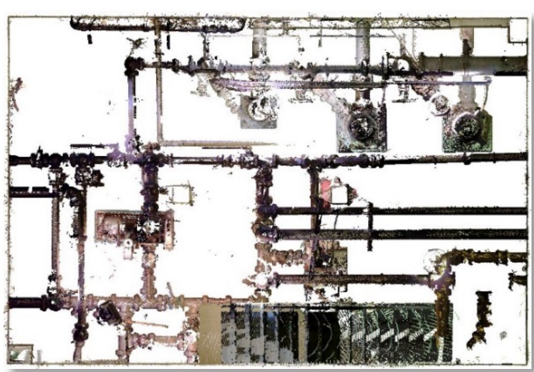
Adjusting the view range in a plan view is key to declutter the scan to only see what is important to model. There is no one range setting that will work. It is dependent on the elevations of what is to be modeled. It is very likely that the view range will have to be adjusted up and down during the course of modeling to isolate what is important from the background clutter. Unless items to be modeled are flush with the floor plane, it is very likely that having the floor in view will clutter up your view more than it will help. In the below examples one shows the bottom of the view past the view vs. the bottom of the view 2" above the floor. As you can see is declutters the view considerable allowing the inside face of the walls, and the equipment to be easily seen and modeled.

View Depth Showing Floor

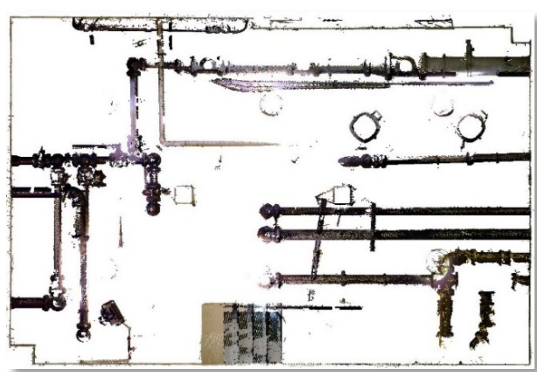


View Depth 3" Above Floor

In addition to the pipe and equipment near the floor this particular level also has quite a bit of pipe running near the ceiling level. By adjusting the cut plane to 9', this shows the piping near the ceiling. But having too large of a range between the cut plan and the bottom, the view can get very cluttered. The below example shows a wide view range and a more shallow view range.



View Depth 3" to 9'-0



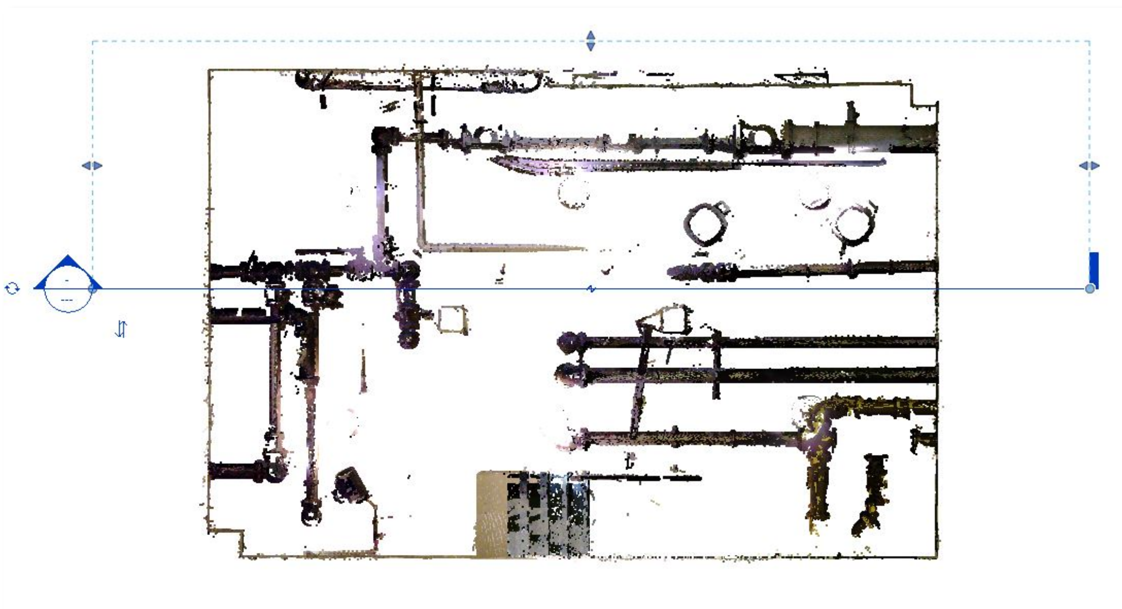
View Depth 7'-0" to 9'-0"

As you can see above, the more broad view range on the left is quite cluttered whereas the more narrow view range on the right removes the lower pipe and equipment and allows you to clearly see the pipe runs near the ceiling.

Again, there is no one view range that will work for modeling. You will have to adjust to the requirements of your project. To know what values to set, cutting a section will help with that. I will demonstrate that next.

Adjusting section depth clipping

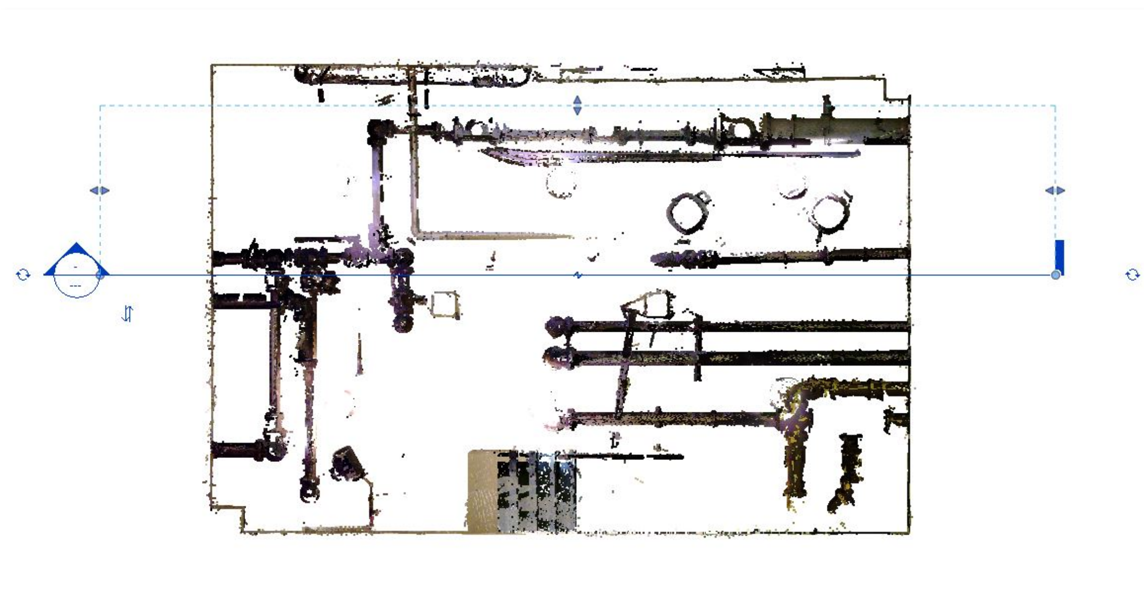
In the below examples you will see that I cut a section through the point cloud. This will help us see where important items lie vertically within the structure and help us set the proper view ranges to isolate the items that need to be modeled. Just like the floor plan, a section that looks too deep can get cluttered especially if it is cut so deep that a back wall can be seen.



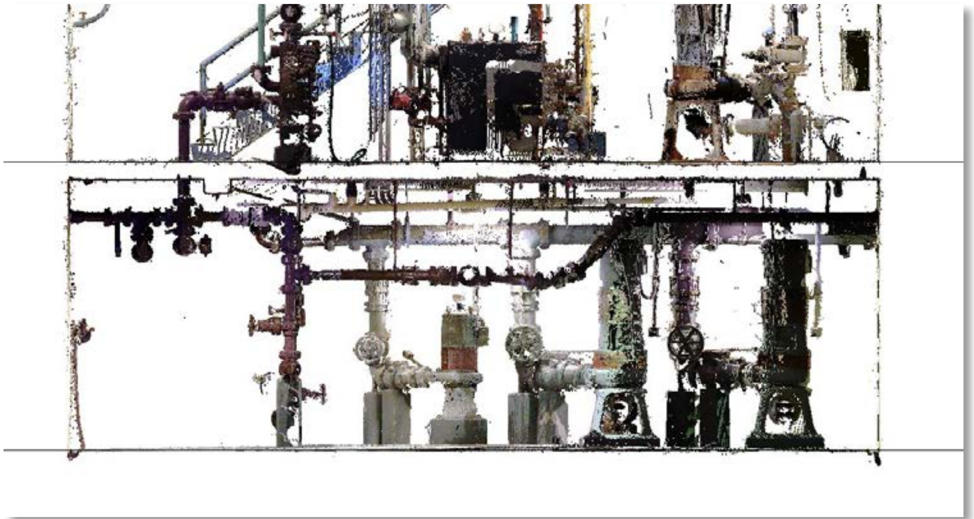
Section depth to include back wall

Back wall in view creates a cluttered section view

Simply by pulling the section view depth a little tighter to eliminate the back wall from view makes the section much more usable to model with. The examples below show that.



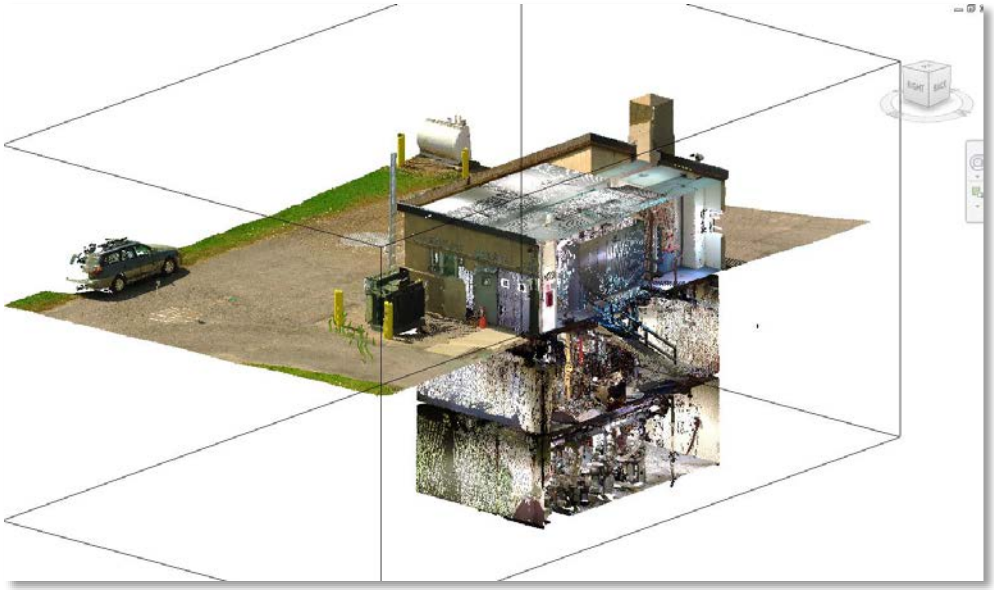
Section view to exclude back wall

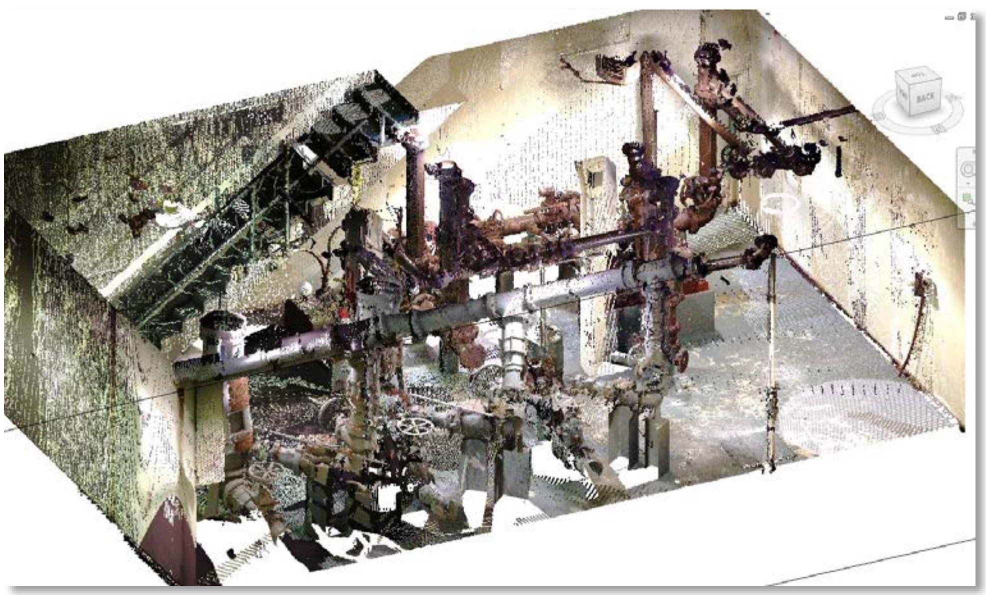


Decluttered section view easier for modeling

Adjusting a 3D clipping box

Lastly we will look at using clipping boxes in a 3d view. While modeling with a 3d view can be quite difficult, using 3d views, especially clipped 3d views can be quite helpful in visualization of the structure and equipment. First create a 3d view of the model. You will then need to create a clipping box in that 3d view. To do that, right click on the view cube in the upper right corner and select Orient View. Then pick one of the options either floor plan or section. Revit will orient your model to that view and clip it to the extents of that view. You can also toggle on the “Section Box” option in the properties pane. This will create a new fully extended section box if one doesn’t exist, or fully extend an existing section box. Now the clipping box is created and you can drag the six sides of it to however you want. Although these views are difficult to model with, they do make great figures or visualizations for design meeting. Below are two examples.





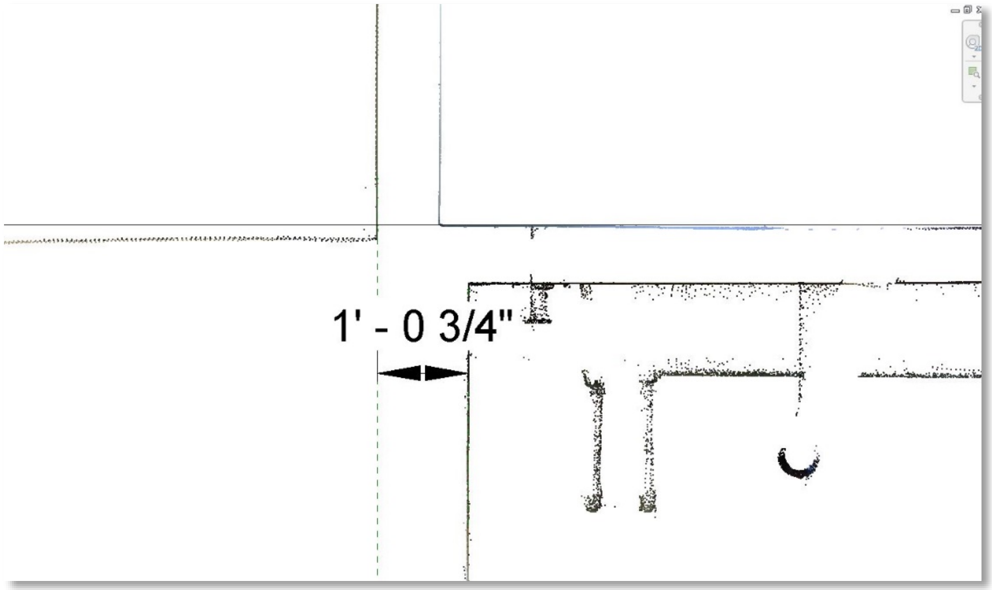
Modeling Architectural and Structural Elements from Scan Data.

Learn how to successfully model in architectural and structural elements with the use of scan data as a reference.

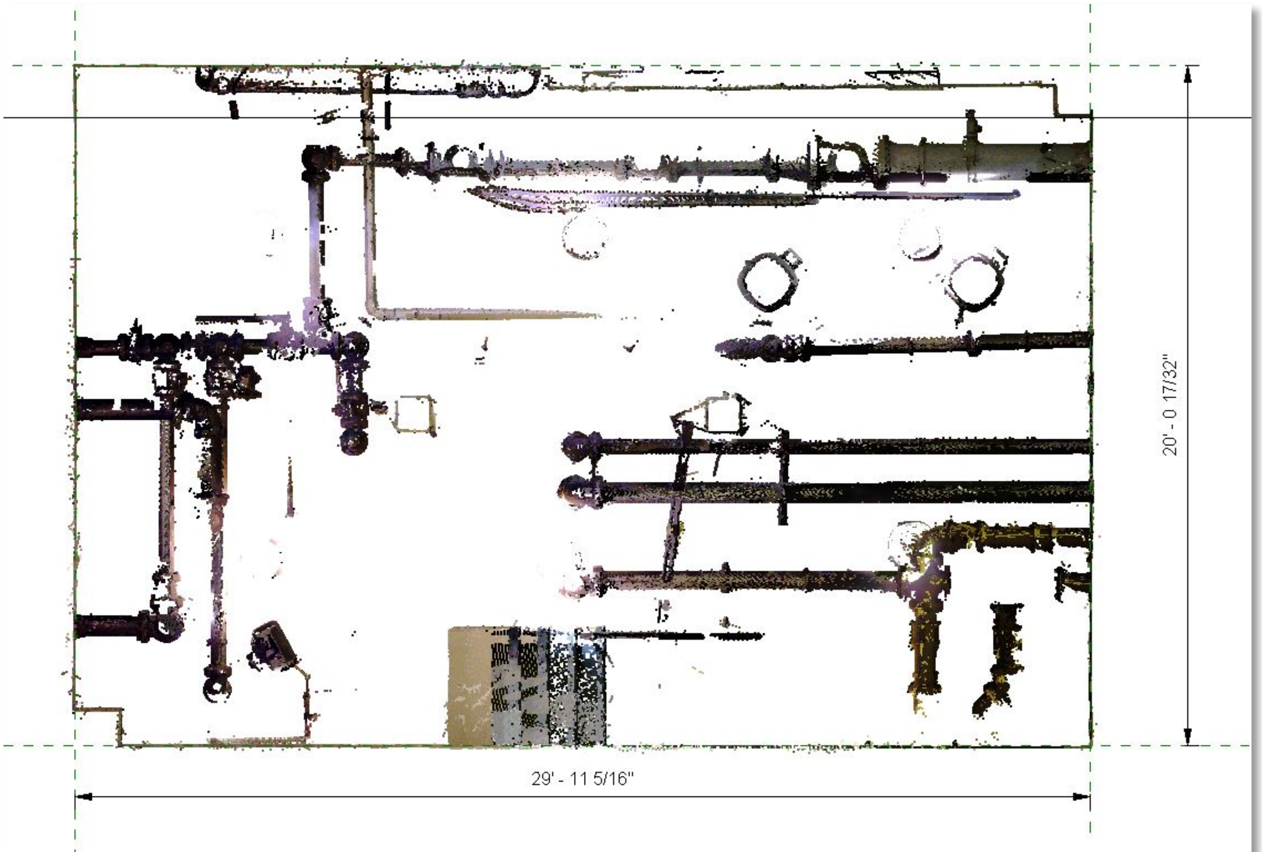
Now that we have successfully imported the point cloud, aligned it, and set up a number of views to help us start modeling, it is time to start modeling. I typically start with the structure of the building before moving on to the equipment within. This includes walls, openings, floors, and internal structure. Items like railing and decorative items can be modeled at your discretion.

The complexity if the model is a decision you will have to make and is totally up to you based on your project needs. For example if the project is to replace some mechanical equipment in a building then much of the architectural detail of the structure is not important. You may only need to show the building in a simplified form. On the other hand if the project is a building addition, you may care greatly about the architectural elements of the structure and will take the time to build complex walls in Revit to match the existing. The process of modeling the structure using a point cloud is the same in either case. In the example below I will use simplified walls.

Typically a good place to start is the exterior walls and from the foundation up. Start by determining the width of the wall. For a foundation wall this may not be possible directly from the scan since the exterior of the foundation may be buried and not visible to the scanner. A section view may help with this. I like to use a very thin section of maybe only 12" deep. In the example below I cut a thin section and am viewing the portion where I can see the outside face of the above grade wall and the inside face of the below grade wall. Assuming the outside faces of the walls align with each other, I can assume the foundation width is 12". You can see that it measures 12.75" but I will go with 12" to normalize things a bit. It is totally up to you what to do as you encounter odd dimensions. You can take them literally or you can normalize them to normal construction dimensions. Different projects will have different needs.

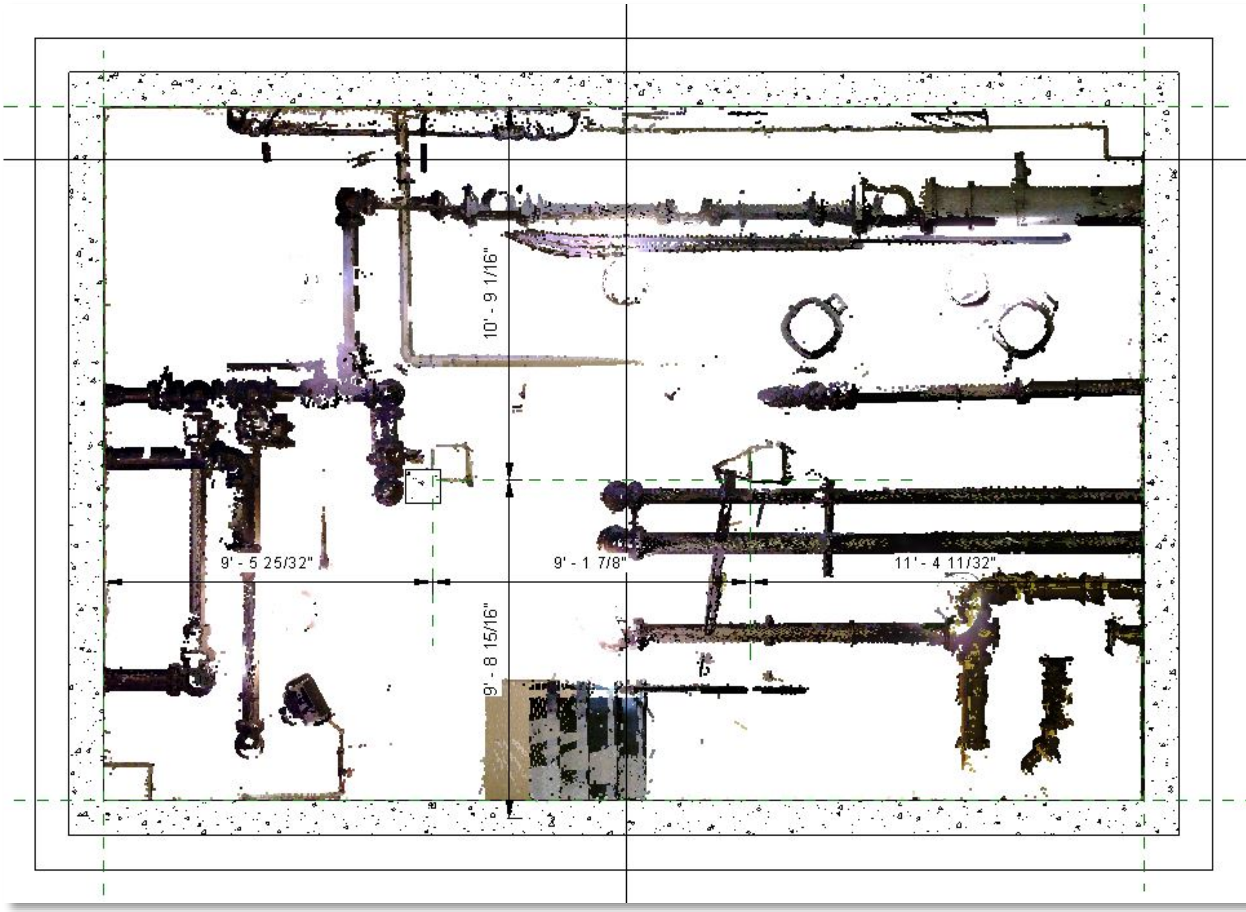


Next, in a plan view with a very thin view depth draw some reference planes that define the interior face of the walls. In most cases I like to use the interior face of the walls rather than the exterior. The exterior surfaces tend to me rougher like split face block or textured precast. The exterior faces can also have architectural reveals or insets so that you may have a hard time defining the actual exterior plane of the wall. For the most part, interior faces are smoother and a plane to define the face can be easily established. Once the reference planes are drawn and aligned to the interior faces, dimension the planes relative to one another. In the example below you can see that the dimensions are slightly off even numbers that you would expect to see. In this case I will normalize the reference planes to 20’-0” x 30’-0”. The degree or normalization you do is totally project specific.



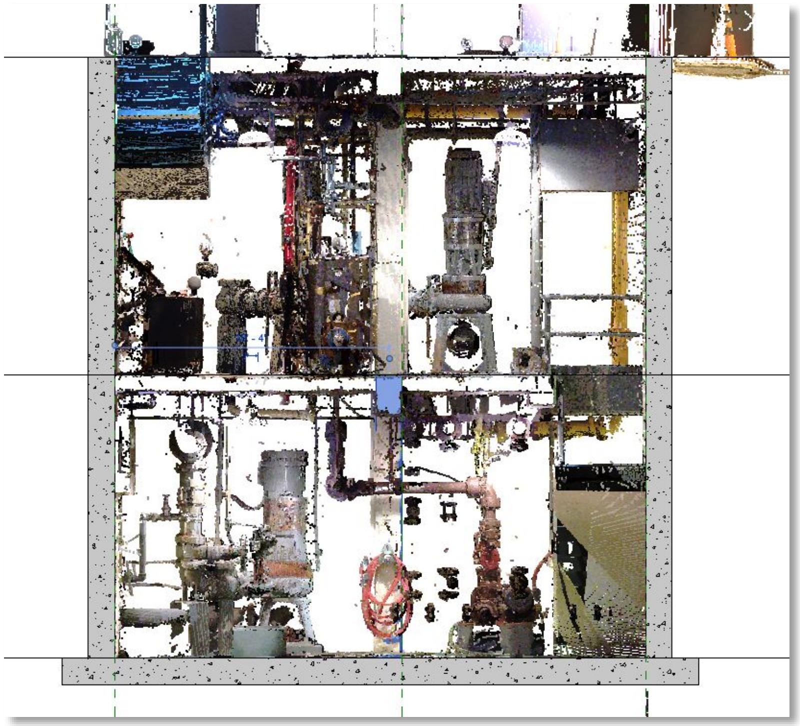
Now these reference planes can be used to model in the lower level walls. I selected a basic 12" concrete wall in this case. I constrained the base to Level 1 (the lowest level) and I constrained the top to Level 3. I could have stacked walls on each level, but for simplicity sake, I just did one wall spanning two floors in this case. When modeling the walls be careful that you are snapping to the intersection of your reference planes and not to the point cloud. Revit allows you to snap to point clouds so it is possible that you are very close to the plane but not on it. If this happens the walls will end up at very strange dimensions. If need be, temporarily hide the point cloud so you do not accidently snap to it.

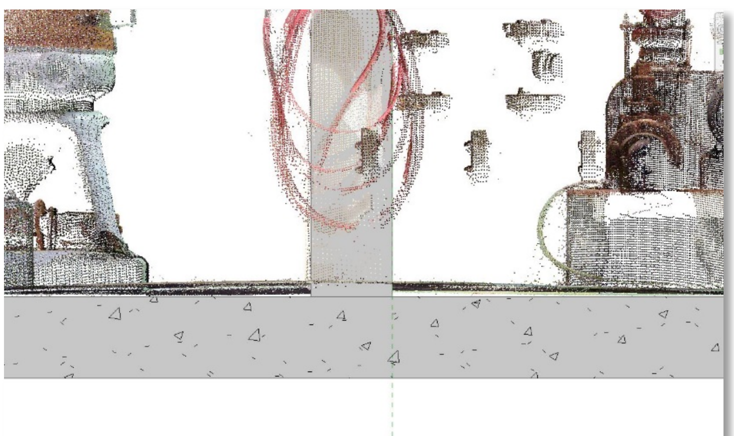
I modeled in the base slab using the walls as a reference. Obviously the laser scan cannot determine the thickness of a base slab nor how far it extends beyond the exterior of the foundation so I just assumed 12" for each for now. For this particular project this does not matter for what we are doing so likely I will just leave it at that. When studying the laser scan you will see that each floor is made from an 8" thick concrete slab held up by a simple pattern of columns and beams. Next I will model in these columns and beams. From here you can establish a grid or use reference planes. In the example I will draw in a couple of reference planes to locate the 12" square concrete columns. Again after the reference planes were drawn, I normalized them to round dimensions. The photo below shows the modeled walls and foundation slab, along with the reference planes for the interior columns before normalizing the dimensions



I now load in the 12x12 concrete column and align it properly with the referenced planes I have created. I adjust the height of the column, in this case constraining it the Level 1 and Level 2. In real world construction you will rarely fine construction that is exactly on and by normalizing dimensions when modeling you will inevitably run into some error. It is a judgment call on how much error is too much. In most cases it is better to live with a little error in places that it does not matter rather than try to model exactly to conditions which can be very impractical and time consuming.

At this point it is advisable, if you haven't already to create some sections and 3d views to check the accuracy of your modeling relative to the point cloud. In the two examples below you can see the walls, foundation slab and columns and how they relate to the point cloud. They are not perfect, but they are close enough for this project. In the second photo you will see how the point cloud floor slab and the modeled floor slab deviate from each other. In the real world, the floor slab has quite a hump in it for drainage to a perimeter gutter drain. In the modeled it is modeled with a flat slab. For this project this does not matter so I will leave it. If it did matter the floor slab could be adjusted by adding points to it adjust its thickness to match the actual floor slope.

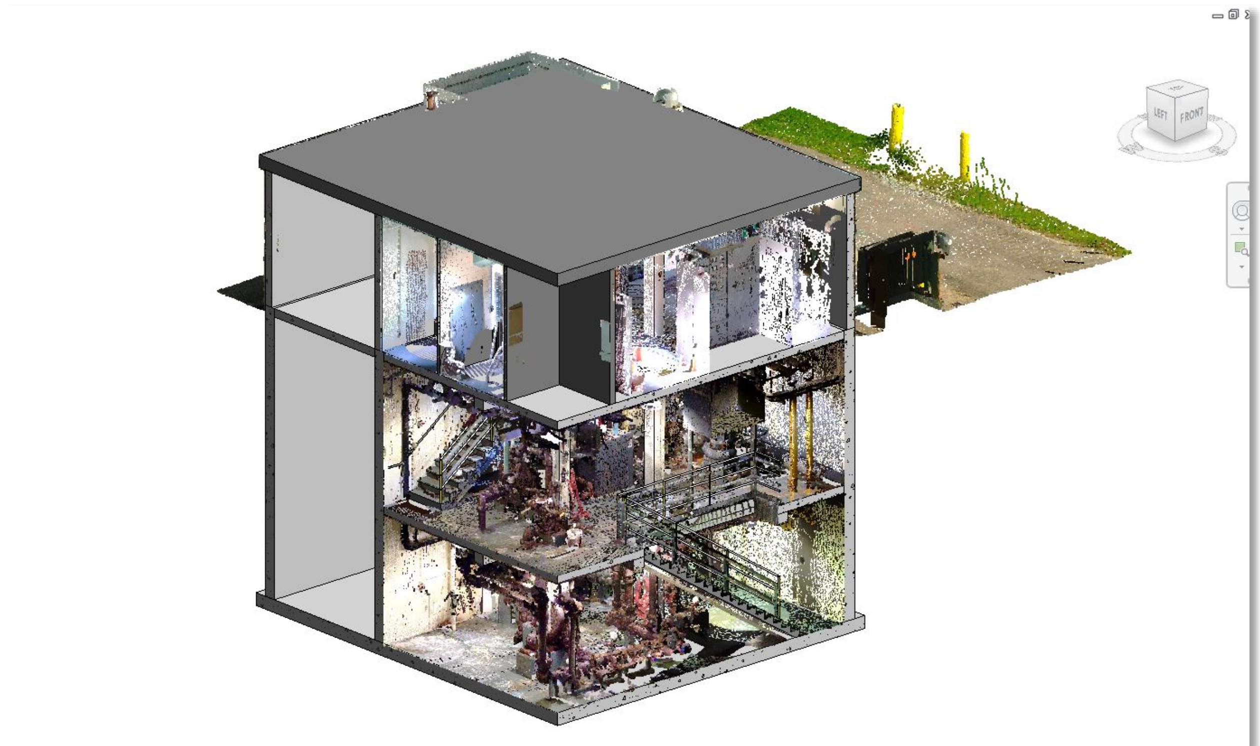




Modeling the rest of the structure follows this same process. Use reference planes to outline features to follow, normalize the dimensions, model the objects using these reference planes, adjust the height constraints, and check your work with sections and 3d views. Placement of doors, windows and other openings is just as simple using the point cloud as a reference and normalizing the dimensions one they are placed.

The next question is, where to stop. The answer to that is very project specific. Do you model in the floor pitch to every floor drain, do you model in every control joint or architectural reveal in a wall, so you model in every chambered corner on beams and columns? That is 100% up to you. The beauty of modeling with point clouds is that you have all that information available to you and you get to decide how far you take it.

The photo below shows the basic structural and architectural model of the building. It has all the walls, floors, openings, beams and columns modeled. For the most part, the model matches the point cloud to within an inch which is good enough for my use.



Modeling Mechanical Equipment and Pipes from Scan Data

Learn how to successfully model in mechanical equipment and pipes with the use of scan data as a reference.

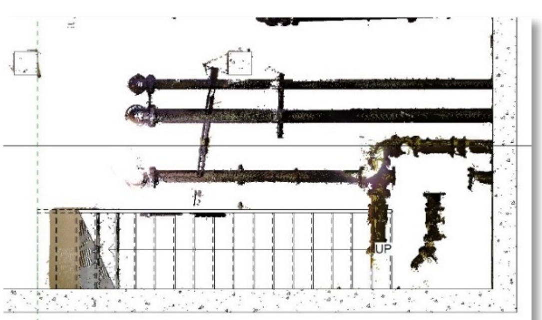
Where to start

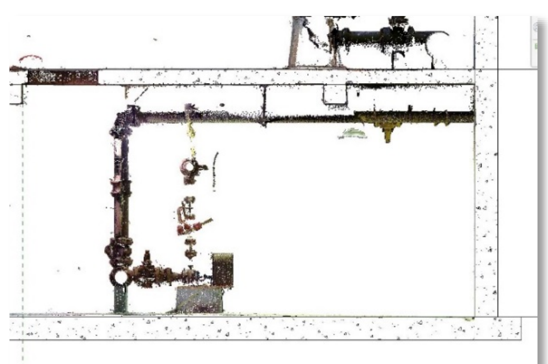
Like most tasks so far, where to start is very project specific. Do you need every pipe run and every piece of equipment modeled? Maybe you don't need anything modeled and you only want to use the point cloud to verify clearance for new equipment. You have to start somewhere. I like to start with major pipe runs and model in pipe only. I may then move into modeling equipment and placing the equipment and connecting in the piping. After that maybe move on by putting pipe accessories into the pipe runs such as valves or wall pipes. There is no one right way to do this so do what makes sense for you.

One question to ask is regarding the creating families of specialty equipment. How detailed do you need to get with that. A piece of equipment could be as simple as cube sized to the bounds of the equipment with a couple of pipe connectors, or it could be a very detailed parametric family with loads of BIM data and pipe and electrical connectors. It is good to answer this question up front. My typical method is to make the family look like the equipment on a basic level and have the appropriate size pipe connectors located accurately.

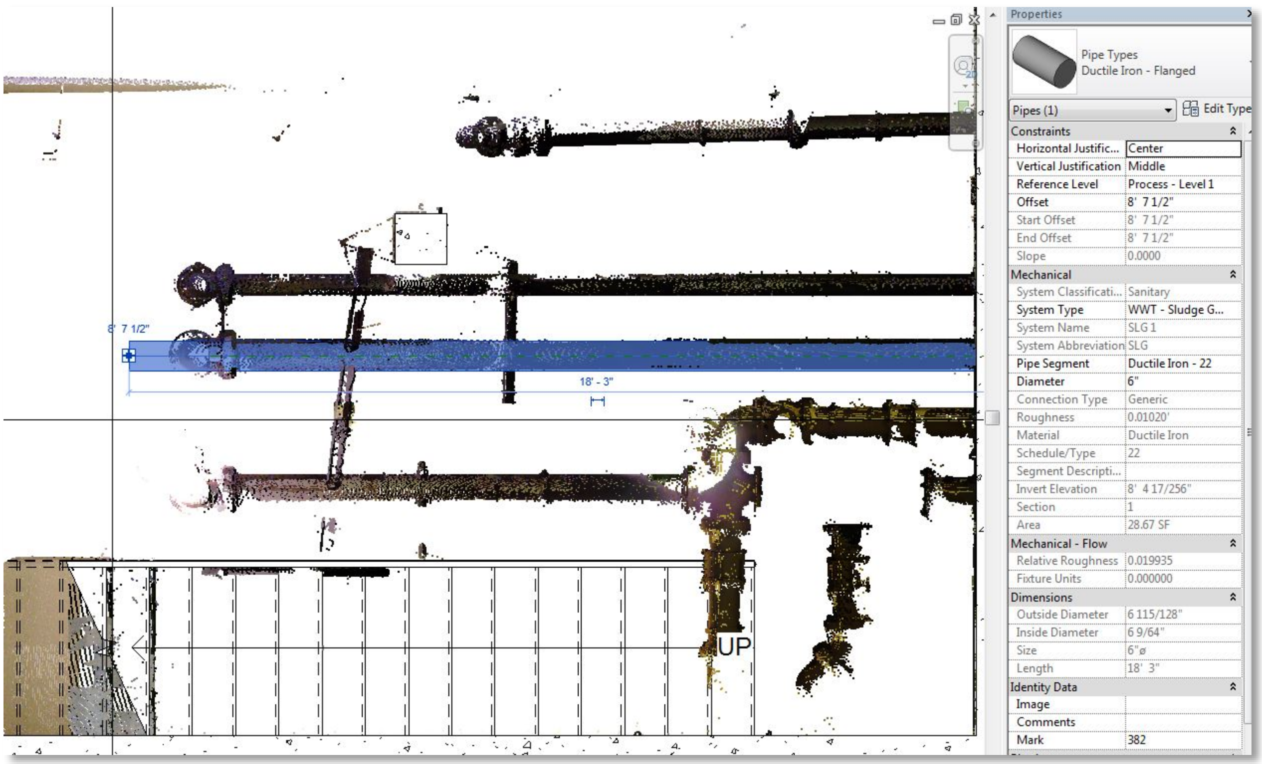
Modeling pipe runs

Just like modeling the structure you need to have views set up with appropriate view depths set to clearly isolate what you are modeling. For a pipe run that traverses in three dimensions, I like to have a plan view, two sections, and a 3d view at hand. Let's start with an easy straight run of pipe near the ceiling of Level 1. Below is a plan view with a narrow view range from 8' to 9'. Also is a section to measure the height above finished floor.



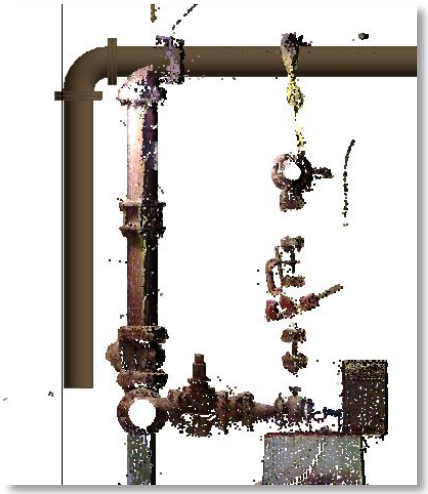


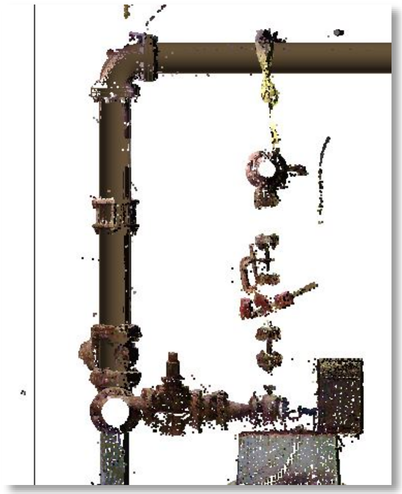
To begin modeling the pipe, first measure the centerline of the pipe above your reference level. Level 1 in this case. Also you will need to determine the diameter of the pipe. Choose an appropriate plan or section to do this. Now in plan, using a reference plane, draw the centerline of the pipe. Now draw the pipe along the reference plane in plan view at the elevation measured in the section. In this case I will used a 6" flanged ductile iron pipe at 8'-7.5" above Level 1. Also set your system type at this time. The photo below shows the pipe drawn in place and the properties of the pipe.



You will note that the pipe is drawn past to the left of where it turns down. I do this deliberately. I like the draw individual runs then align them later. Find whatever technique works best for you.

Next in section view I draw the down leg of the pipe then align it with the point cloud. These steps are shown in the photos below.





For the next run of pipe which the 4" pipe directly north of the one that was just modeled, I will have to use a different strategy. The reason is that these two pipes join each other in a flange on flange fitting. Revit will not allow a user to model flange on flange and even if it did it would be very hard to draw the pipes the exact distance apart for flange on flange to work. I will model it in plan view just as I did before but deliberately not aligned with the point cloud. I will finish up by modeling in the fittings that the pipes will join each other with then move the pipe into place after that matching the flange faces of the fittings. In the photos below you will see the pipes modeled with the appropriate fittings, but purposefully far apart from one another. The next photo shows the pipes moved into the correct alignment to the point cloud by joining the flanges of the tees.

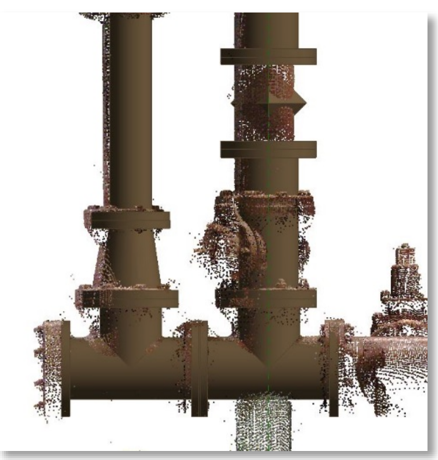
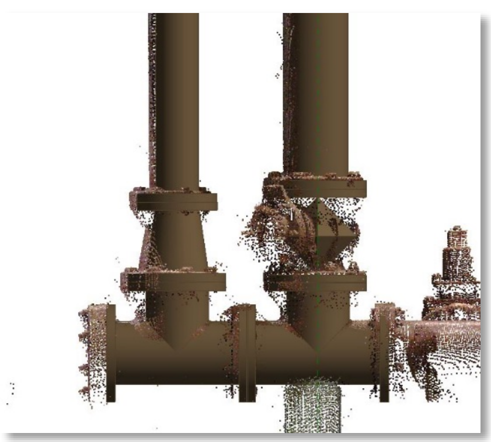
As you begin to model pipe runs you may begin to notice that your pipe and fittings start to not line up with the point cloud. In the real world, pipe is rarely square with the walls, plumb, or level. It is extremely difficult to account for these slight variations with modeled pipe. I find it best just to find a centerline or a plumb line that works "good enough". Model the pipe true to the point cloud where it matters most, and let it deviate where it matters least.

Also this is a good time to talk more about Revit and fitting on fitting situations. The bottom line is that Revit does not work well with fitting on fitting pipe situations. The only real out of the box solution is to model out of place and to move it in line afterwards like in the example above. To elaborate further though, you may find that later on you will get errors when trying to connect to pipe runs that you have joined with fitting on fitting connections. This is because the modifications you did to the pipe may have caused Revit to redraw a particular pipe run that ends in a fitting on fitting connection. A solution to this is to leave some of these fitting on fitting connections with a slight gap until the pipe is mostly modeled. Once you are done modeling full pipe runs, then align the fitting on fitting connections that are required.

Placement of pipe accessories in pipe runs

Just as with the fitting on fitting problems you will encounter when modeling pipe runs, you will encounter the same problems when placing pipe accessories. I the next example I will go over placing a 6" flanged plug valve in a pipe run flange to flange with a tee.

Select a view that works for you. In this case I will select a section view that clearly shows the plug valve. I first insert the plug valve in the pipe run well away from the tee it is directly bolted to in the point cloud. I then delete the spool piece between the valve and the tee then move the valve into place against the tee.

It may help to look at the point cloud, remember what you need to model then model with the point cloud off. Since the point cloud is able to be snapped to, you may be inadvertently snapping to the point cloud rather than where you actually want to on pipe or fittings.

Modeling mechanical equipment

It is assumed you are familiar with family creation in Revit. Most of the time I am creating families to model mechanical equipment. I like to use the Mechanical Equipment family type rather than a generic model. This is because mechanical equipment families do not cut in plan or section. Most of the time you would want to see the full piece of equipment rather than a cut through it.

Unfortunately a point cloud can't be referenced into a family in Revit. Being able to directly model a family on a point cloud in Revit would be a huge advantage, but as of now, it can't be done. The model in place feature will work, but it is a bit limiting in that it is more cumbersome to work in than the family creator and the final component is not a separate family, but rather contained within the main model.

I prefer to work in the normal Revit family creator where I measure in the point cloud and model in the family creator flipping between screens. I will measure in the Revit project and model in a family creator.

Below is an example of a large centrifugal pump that was created with basic shapes in the Revit family creator. I used plan and section views to measure critical dimensions of the pump and modeled it. This model has two pipe connectors to join into the piping system.

On the left is the scanned point cloud version of the pump and on the right is the modeled version of the pump. The level of detail that required in your family is up to you. For this project I wanted it to look generally like the pump, I needed its base, overall height and diameter to be dimensionally accurate. Of course the most important thing for me was the size, location and orientation of the connectors.

To create visual detail in a family without making the family overly complex consider two dimensional model lines on a surface to visually create detail such as vents, gratings, control panel buttons, etc.

Summary

Although there are automated tools out there developed to automate the process of developing a model from a point cloud, the knowledge and skills needed to manually do this task are still very important and relevant. There are many situations on every project where this skill has not been replaced by an automation. Automation has its place, but when real life conditions deviate too far from what the automation can handle, that is where your skills are needed.

Thank you for attending this class. Every situation is unique and we certainly can't even begin to touch all the scenarios out there, but hopefully this class has given you the basics skills to efficiently model your next project from a point cloud.