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Managing BIM Projects Without Going CRAZY

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Learning Objectives

- Discover key points for the project execution plans and staffing
- Understand how to clearly define CAD and BIM tasks for a project, and learn how standardization between both should be approached
- Learn how to migrate third-party content and filter essential data into a project family
- Examine different levels of development, and understand when to use design versus fabrication tools

Description

This course will cover effective practices for project managers, architects, engineers, and designers working on Building Information Modeling (BIM) projects for all areas of architecture, structure, and MEP (mechanical, electrical, and plumbing) systems. Learn how AutoCAD software and Revit software have altered the traditional design workflows and processes, and discover how to manage the disruptive changes. The course will cover pre-project planning, as well as deal with project content and understanding what tools can really help a project's bottom line. We'll also review key CAD and BIM standards, and explore where Revit software alters typical project tasks for higher levels of development. The course is well suited for the first-time manager and experienced user.

Speaker(s)

David Butts is an Autodesk Expert Elite Team member and Building Information Modeling (BIM) specialist for Gannett Fleming with over 30 years of experience in the architecture, engineering, and construction field. He is responsible for implementation, training, BIM project support, and management for engineering design applications, including Revit, AutoCAD P&ID, AutoCAD MEP, Navisworks, and more. He was an Autodesk Authorized Training Center (ATC) training manager and application engineer for an Autodesk Reseller for 13 years, providing implementation and training services across the United States, and serving as a subject matter expert for Autodesk, Inc.'s, Building Design Solutions. He has design experience for a variety of project types, and is an Autodesk University top-rated speaker for labs and lectures. He authors training videos for 4D Technologies, and he presents BIM topics for other industry associations annually.

Managing BIM Projects Without Going CRAZY

I'm an old dog, and have been around the industry for a long time. I've been fortunate to witness the evolution of our design tools in a way not thought possible three decades ago, and while we may not be in Jetson-style flying car, we've definitely pushed the limits of the software – and user's – capabilities. And it's a good thing, since pushing both to do more, and better, is what helps us grow. BUT...sometimes, we get moving so quickly, that we miss things we shouldn't, or we try to go too far running when we should be walking.

This course is actually about STOPPING – backing up, taking a deep breath, and figuring out how to really get into the meat and bones of the Building Information Modeling *process*. Too often we're not aware of how the process changes the very essence of how we've completed projects, and how new tasks need to be understood before starting the job. We also need to learn what we don't need to be doing anymore, and what's changing in the project deliverable set.

So, there are four areas we're going to review. The first backs the team up to day one, and covers the project execution plan – its key points, and how to properly staff a project so you can meet the goals of this critical document. The second topic covers understanding how BIM and Revit alters CAD tasks, and how it affects your project schedule and timeline.

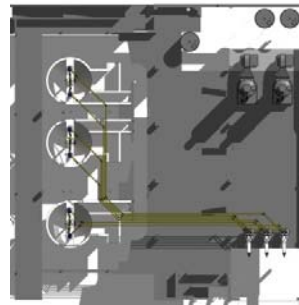
The third section covers how the defined BIM goals affect one of the more critical phases of a project. The example used displays the difference between traditional critical equipment selection and indication in a document set, and what the BIM project requires that changes everything.

After these points are hashed out, the third topic covers the part that vexes most project managers, architects and engineers – how to change from a 2D symbolic content to third party content from vendors, and how to determine the key data that should be included. We'll wrap it up in the fourth segments reviewing level of development impact your workflows and methodology, and how to determine where design ends and fabrication begins.

Now, it's time to take those straitjackets off, and free yourself up to move to the next level...are you ready?

Managing the Project Execution Plan and Proper Staffing

What types of projects does your firm design?



It doesn't really matter what you're designing – if you don't have a plan for integration of BIM work processes, and the right staff to implement it, you run the risk of losing money on your work. It's important that with any disruptive change in a business you have to learn how to adapt to the craziness that is involved in managing a BIM project.

Deciding Go or No Go on BIM Projects – Before the Project Execution Plan

The first step that most companies fail on, when it comes to planning for a BIM project, involves the Risk Assessment, during the proposal process. It's critical to know what the deliverable requirements are, including:

- Required software package and version
- If BIM, then the Level of Development required
- Ancillary packages that are linked to the design software – energy analysis, specific object modeling (bridges, roadway, process, etc.)

When making the **Go/No-Go** decision to pursue a project, it's critical that project managers and planners understand what these requirements are. All it takes is one missed sentence in an RFP - failure to do so can result in missed costs, such as those involved with the purchase and training of a software package such as Revit. Influencing factors should include the following items:

- Is the client requiring BIM as a deliverable?
- Does the client require specific software and version?
- Does the client demonstrate understanding and expertise with the required software and deliverables?
- Does the client include standard files, such as templates and content?
- Does the client require interaction with data, which is associated with the model, for life cycle and asset management?

With all of this said, an RFP that does not include these items does not preclude your firm from using BIM as a tool. Understanding the client's expectations, and making sure you can meet them, is the critical first step.

You've Won the Project – Now What?

Now that you've successfully won the work, you probably have some good traditional workflows that help setup and organize a project. But what if this is your first BIM project...or worse, you worked on one before, and failed? More often than not, projects fail because of poor design practices than as a result of implementing and using new software and techniques. Once item you'll find is that the BIM workflow tends to uncover these weaknesses in your traditional process.

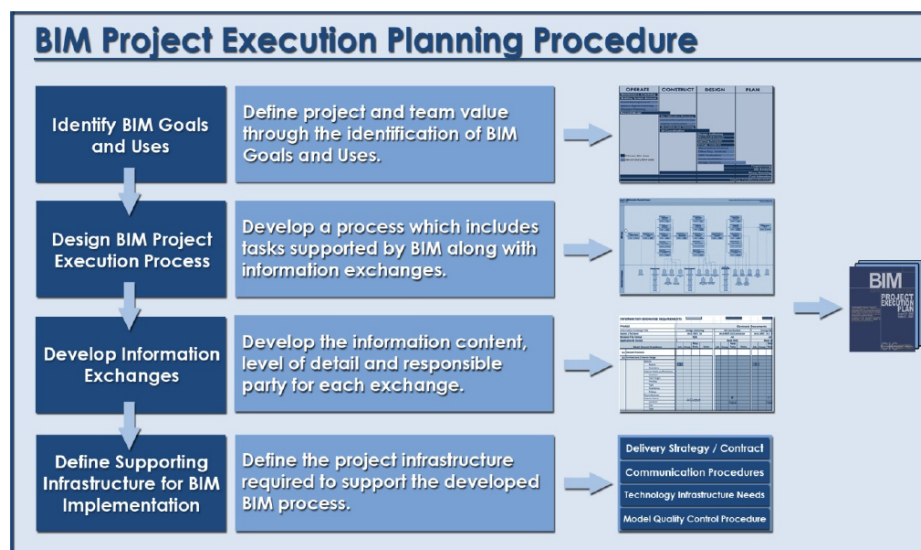
The BIM workflow can be more restrictive, with requirements that some tasks actually being completed before moving on to other areas. In addition to setting overall project goals, the Project Execution Plan, or PXP, can contain much more detail that helps a project stay on track.

The National BIM Standard, US Version 3 (<https://www.nationalbimstandard.org/>) includes guidelines about this workflow. This document is intended to "encourage further productive practices by all members of the architect/designer, engineer, contractor, owner, and operator (AECOO) team for the life-cycle of a project. This and succeeding versions will provide the necessary structure and framework for a collaborative basis for the process, the ethics of trust between the professionals, the standards for building information technologies, and a system for

an integrated practice within an open, nonproprietary, standard accessible to all professionals within the industry.”¹

While a newer version of the NBIMS is in development, this document provides the foundation for what BIM standards can look like. One key area, in Chapter 5.3, addresses the **BIM Project Execution Planning Guide**. There are four key areas a “PxP” must address, in order to make sure you are meeting your goals.

1. Identify goals and high values BIM uses during each project phase
2. Design the BIM Execution process through the creation of process maps
3. Define the BIM deliverables in the form of information exchanges
4. Develop the infrastructure to support the implementation such as contracts, communication procedures, technology and quality control.



The BIM Project Execution Planning Procedure, National BIM Standard, Penn State, Figure 5.3.1

To boil this down into simpler detail, you need to look at these items prior to starting a project, and making sure you understand the tasks related to each step.

¹ buildingSMARTalliance, “National BIM Standard – United States Version 2”, www.nationalbimstandard.org 2012

Identify BIM Goals and Uses, and Identify Staff

When deciding how BIM will be used on a project, you need to ask these questions?

1. *What parts of a project will be modeled, and what part will continue to be produced in CAD?*

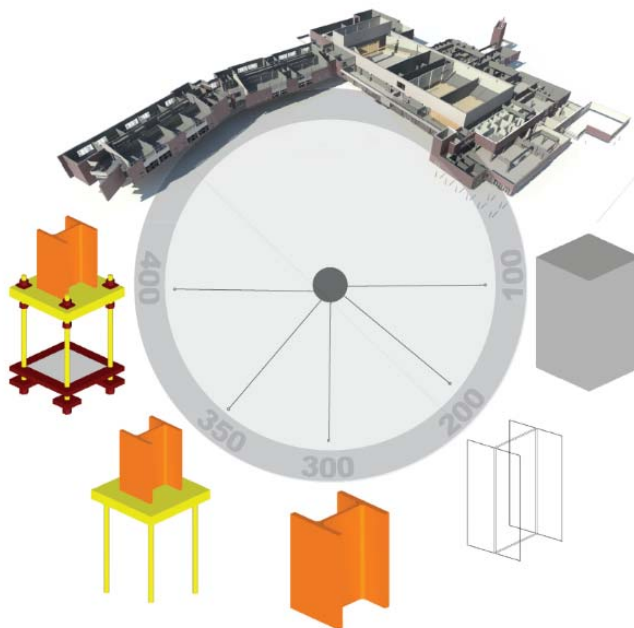
Most new users have the impression that on a BIM project, everything will be produced within that one document. But this is rarely the case, since there are still parts of project that BIM tools don't easily address. For example, on a water treatment plant, a process flow diagram has to be defined first, which explains from a graphical standpoint how the treatment process is defined.

Once the process is defined, a model of the equipment and associated components – piping, accessories, power supply and more can be defined. But there are small components that may not need to be indicated in a model. In this case, a process and instrumentation diagram is created, and produced as a CAD document. Autodesk addresses this with the AutoCAD Plant 3D application, which is a SQL database driven CAD file.

Other types of 2D documentation that is still CAD produced includes power diagrams, plumbing riser diagrams, and standard details that provide additional detail that is not included in the model.

2. *How accurately should the model represent the actual conditions of the finished product?*

At the start of the project, you decide to what level of development, or **LOD**, is going to be used. You may already be familiar with this standard, since the AIA addressed this several years ago, when BIM was starting to become more widely used. The original E202 document from the AIA was update and revised to G202-2013 in June, 2013.



LOD Examples

The levels are defined as such:

- **LOD 100:** The Model Element may be graphically represented in the Model with a symbol or other generic representation, but does not satisfy the requirements for LOD 200. Information related to the Model Element (i.e., cost per square foot, tonnage of HVAC, etc.) can be derived from other Model Elements. *We use this level in the early design stage for energy analysis, orientation and other early design decisions*
- **LOD 200:** The Model Element is graphically represented within the Model as a generic system, object, or assembly with approximate quantities, size, shape, location, and orientation. Non-graphic information may also be attached to the Model Element. *Most of our existing model conditions are represented at this level.*
- **LOD 300:** The Model Element is graphically represented within the Model as a specific system, object or assembly in terms of quantity, size, shape, location, and orientation. Non-graphic information may also be attached to the Model Element.
- **LOD 350:** The Model Element is graphically represented within the Model as a specific system, object, or assembly in terms of quantity, size, shape, orientation, and interfaces with other building systems. Non-graphic information may also be attached to the Model Element. *Our primary design goals are to model to this level for all projects, as specified in the contracts.*
- **LOD 400:** The Model Element is graphically represented within the Model as a specific system, object or assembly in terms of size, shape, location, quantity, and orientation with detailing, fabrication, assembly, and installation information. Non-graphic information may also be attached to the Model Element. *Some parts of our projects reach this level, when we can obtain the actual equipment to be used. Design-Build is more likely to use this level.*
- **LOD 500:** The Model Element is a field verified representation in terms of size, shape, location, quantity, and orientation. Non-graphic information may also be attached to the Model Elements. *This represents the as-built conditions with data correctly associated, for OMMS and other post design application.*

With most design firms, you need to know when to apply these levels. For example, your project may involve the requirement of providing an as-built model, to represent existing conditions. Laser scans, which help with the 3D component, may fall short when it comes to representing the exact, object-based elements, which are recognizable as BIM objects, and require data association. In this case, you should at least limit your **LOD** to **200** for existing conditions, so you are not liable within the model of representing what's inside a wall, or fully enclosed and difficult to verify.

But new work in the model can easily be represented at **LOD 300** and above. It's critical to check the initial RFP and understand what the client will be expecting – you don't want to budget for 350 if you are the design team, but then be required to deliver 400, without understanding the consequences.

3. *How do I select the appropriate staff for the project?*

This is usually a tough item, especially as companies work to deal with reduced margins, and higher expectations of the client and the deliverable. The design team must be capable of adapting from the traditional, CAD-based drafting mode, to the model and data based environment of the BIM team. Planning for and addressing staff issues for effective use of new technology, and preparing a training program is critical – if you are responsible for managing the implementation of BIM into your firm, you have to accept these facts:

- Your STAFF is the key to success

- Your UNDERSTANDING of today's tools is critical
- TRAINING is forever – it's better to train them and have them leave, than not train them and have them stay
- IMPLEMENTATION is the BLOB – it goes on forever...!
- **OVERCOMING THE FEAR OF CHANGE IS PARAMOUNT!**

Understanding skill levels from project management to design staff are critical, so here are some requirements:

- **The Design Professional/Project Manager:**
 - Understanding of BIM work processes and methods
 - Understands task allocation, time and CAD/BIM differences
 - Strong Vendor Relationships
 - Ability to work in different software environments with ease
 - Ability to LEARN and adapt new features, methods, and follow company SOP's
 - Ability to clearly communicate
 - And most of all, professionals are **NEVER** above using the software, just as a technical team member would be – it should be encouraged!
- **The Technical Staff**
 - Design experience, not just drafting – and willing to put in the required effort
 - Ability to work in different software environments with ease
 - Ability to LEARN and adapt new features, methods, and follow company SOP's
 - Ability to visualize and work in 3D environment
 - Ability to clearly communicate
 - Contribute to improving standard procedures and work methods – don't be afraid to question the "way we've always done it"
 - Willingness to take ownership!

4. *Once the staff is assigned to the job, how do I make sure they can do the work the way it needs to be done?*

Did this ever happen in your office? You won work, the contract was awarded, and the PM shows up. They tell you that you've got to use XYZ software, and the project budget is tight, so go get a book, and learn how to use this on your own.

This is the #1 recipe disaster for failure on a project – where I'm from, we have a sporting challenge for these kinds of managers (don't worry, we give 'em all 3 bottles of water, a mobile phone with no email and half dead battery, and a 2 minute head start).

The reality for today's design firm:

- *Training is REQUIRED AND ONGOING!*

You should have a plan for making sure that you and your staff can get the adequate training needed to use today's tools. These applications are NOT simple – in fact, they can get quite complex. As the LOD on the project goes up, the understanding and skill level must increase as well.

- *Start with Trusted Advisor!*

There has to be someone that can offer you guidance, and it can come from a variety of sources. A true trusted advisor will be the one that has the product and process knowledge for BIM, and be able to help you relate the traditional to BIM transition in a way that makes sense. Most good advisors will learn how you learn, then recommend one of these options:

- Instructor Led
- Online – Live
- Online – Video
- Books/Manuals



In many cases, it won't be just one of these options, but a combination of all of these. Keep in mind the first project hurts; the second, not so much; and by the third, you should be on your way.

- *Develop in house Expertise – the Subject Matter Expert(s)!*

For ongoing success, you need this person more than anything, but you have to be picky about who this is. Characteristics of a good expert include:

- Willingness to adapt, and learn with an open mind
- Capable of taking into consideration the opinions and ideas from others
- Understand that their role, above all, is to be in service to others. It's not about them!

- *Have a well-formed training plan, based on the staff*

If you try to teach a cat how to sit, roll over and beg, you're going to have some issues. Training engineers, managers and technical staff can be widely varied, so having a training plan that fits the individual is critical. Here's how our firm addressed training for the design teams:

- *Management – Corporate and Project*

- BIM Overview
 - ROI Areas – Cost/Benefits
 - Software
 - Hardware
 - Training
 - Support
 - Workflow Adjustments
 - Legal Requirements/Risk Assessment
 - Contractual
 - Marketing
-
- *Engineering Staff*
 - BIM Overview
 - Tools to Task – Traditional versus BIM
 - Data – Excel vs. Model
 - Internal vs. External
 - Sizing
 - Analysis
 - Workflow Adjustments – The Four Step Process
 - Legal Requirements/Risk Assessment
 - Coordination
 - External Analysis Applications/Integration
 - Compatibility
 - Compliance
-
- *Technical Staff*
 - BIM Overview
 - Tools to Task – Traditional versus BIM
 - Discipline Specific
 - Workflow Adjustments – The Four Step Process
 - Creating the Model the Right Way!
 - CAD Integration
 - Documentation Process
 - Content Development

- Standards

- *BIM Management*

- Project Setup/Management
- Tools to Task – Traditional versus BIM
 - Discipline Specific
- Workflow Adjustments – The Four Step Process
 - Creating the Model the Right Way!
- CAD Integration
- External Software Integration
- Documentation Process
- Content Development – Third Party Modeling
- Standards

Selecting and Adding Equipment – It's Time to GO!

You've reviewed the contract and know what is required. You've picked the staff, and set them up with training. Now you're ready to start on the project, and you get smacked in the face with your first BIM challenge – and it's got nothing to do with CAD. As an MEP or Process engineer on a project, the primary components that define your systems start with the equipment. You've got know a lot of information before you can even start to put pencil to paper...or, push mouse to ribbon.

This is the first example of how a BIM project differs from a traditional job, and where you need to start. The scenario is: We're designing a maintenance facility, and we have industrial equipment that's provided by the client, mechanical service equipment that's part of the building, and electrical equipment that powers it all. One of the first things we taught our project manager was the information and content we needed, and why it was needed earlier – not later – in a project.

Traditionally, electrical data is usually one of the last items addressed in a project. You want to have everything in place before you power it up. And that's fine – except in many cases, that data doesn't arrive in the engineer's hands until a few days before the document set is due. Our goal was to change that practice, so it also meant a change in how we dealt with our vendors, and how we selected and placed equipment in the model.

Developing Equipment Lists

At the start of the project, you want to gather as much information about project equipment in the early phases of design – preferably in schematic design. The size, orientation, clearance and access requirements drive the design in this scenario. In Revit, we define equipment (or source) families based on two primary categories – **mechanical equipment** and **specialty equipment**.

Mechanical equipment is defined as servicing equipment related to the operations of the building. It's purchased and located by the general contractor and their sub-contractors. Examples of mechanical equipment include **fans, boilers, air handling units** and more. This type of equipment usually includes one or more electrical connections that's built into the model. It's not unusual for an air handler to have two different voltage connections, based on the components that make up the unit.

Specialty Equipment is used to create models of owner provided equipment. This can include examples such maintenance tools, fueling systems, and conveying and lift components. Most specialty equipment is connected via plug loads, but in some cases, **disconnects** or **terminals** are provided as fixtures, which carry the load data.

All of this is key to the electrical engineer, who will be powering the entire system. Their responsibility is to place the power distribution, generation and terminals needed to make everything run. They can't move forward until the owner of the equipment – the mechanical or industrial engineer – provides the electrical data they need to move forward. While some assumptions can be made, the sooner this information can be passed on, the better.

Start with your equipment list. Traditionally, this is made up of a spreadsheet, which lists the key ingredients and adds some basic data. In our world, we like to take it one step further. We've built a system that integrates the data directly into a SQL database. This not only gives us the ability to track the data, but to coordinate it with all disciplines.

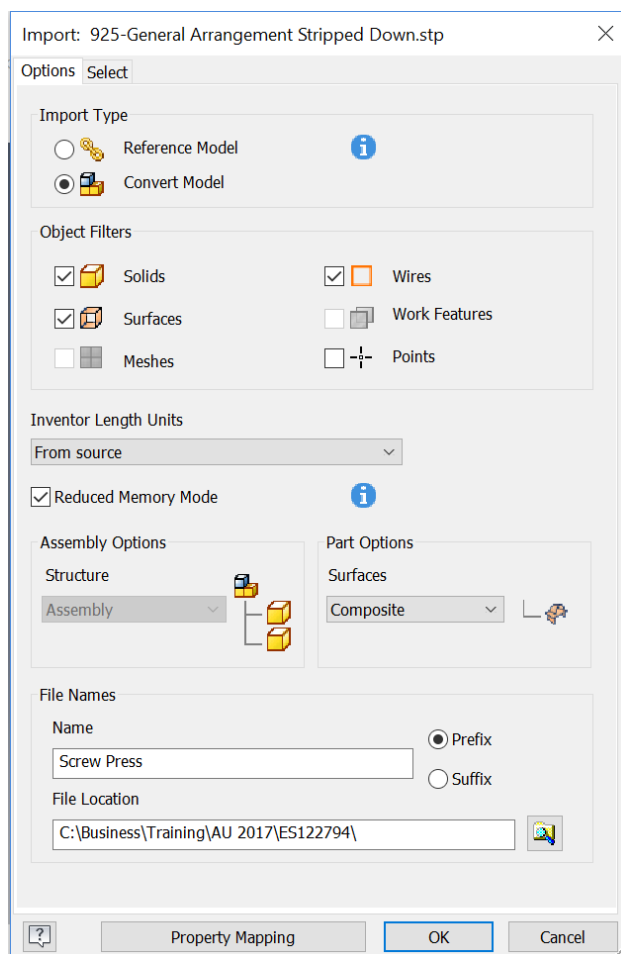
STP, and convert them to an ADSK or RFA file. Getting an Inventor model is a bonus – now that our vendors that use Inventor have figured out they can do the Revit file export for us, we're starting to see more of this. You're looking for as close a representation of the real world part as possible, but it only has to be accurate where connections are made, and clearances required.

The next few steps are a quick overview of using Inventor to convert non-Autodesk files to Revit Families.

Using Inventor to Convert 3D Models

Autodesk Inventor is a “must-own” product for anyone that works with vendor provided content. The application can open nearly any type of modeling file, and easily converts them to either parts (.IPT) or assemblies (.IAM). While these steps do not go into great detail, they give you an idea of how simple it is to work with these models, using the 2018 versions of the software from Autodesk.

1. In the program, start by opening a model file. This example was based on a STP file provided by a vendor (**Spirac, www.spirac.com**) for a waste treatment plant project. Depending on the part type, Inventor will give you several options prior to opening the part:

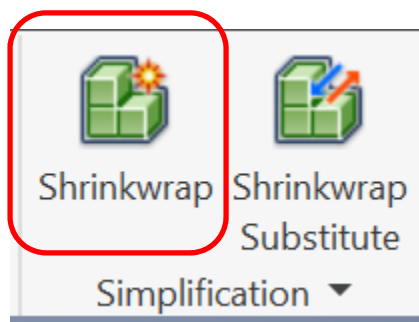


2. You can choose whether or not to include **solids, surfaces, wires** and/or **points**. By selecting the **Import Assembly as a Single Part** option, an **.IPT** part file will be created. Otherwise, an **Inventor Assembly (.IAM)** file will be created. You'll want to experiment with both types, depending on how the model was defined, and how well the export works. Also, make sure you check the **units**, and match what you expect the target file to be based on. Once file is open, the model will appear:

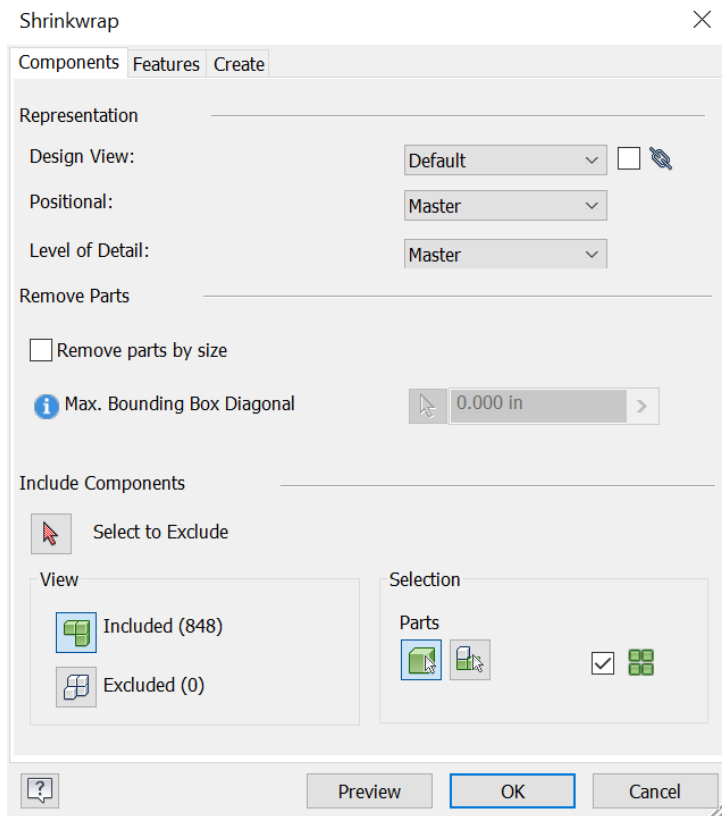


3. Once the part is open, if it is recognized as an **assembly**, you can select individual parts, and edit them using the **Open** command on the **right click** menu. The parts can be edited, or opened separately (for example, if you want to remove the detail from the press, include nuts, bolts, etc.). You can also export the components when opened as parts.

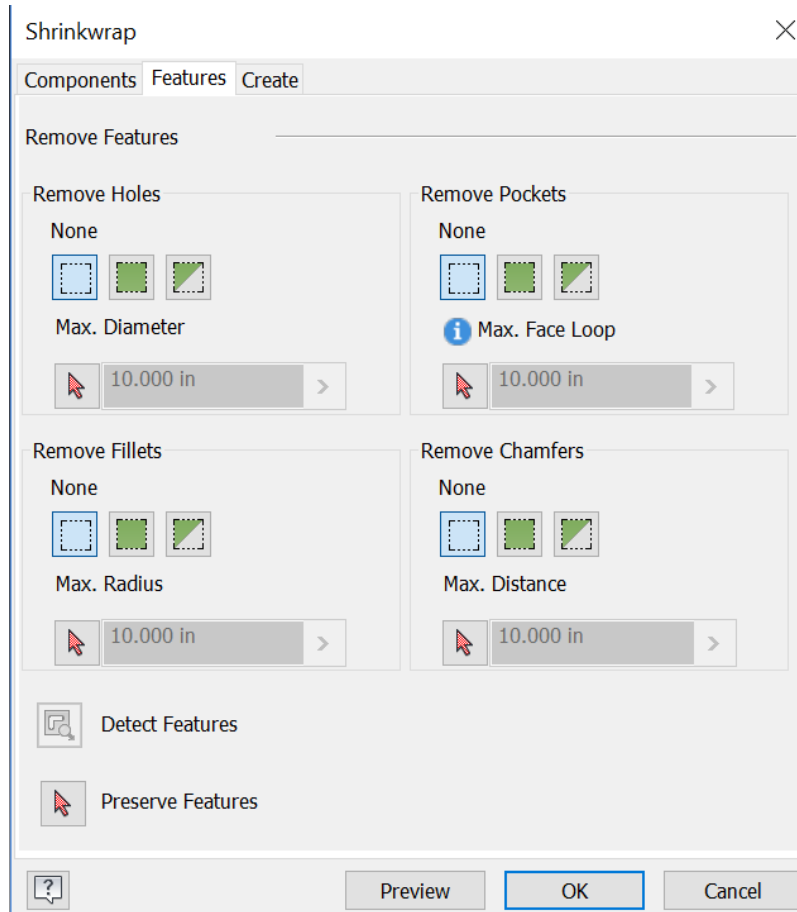
4. From the **Assemble** ribbon, select the **Shrinkwrap** tool:



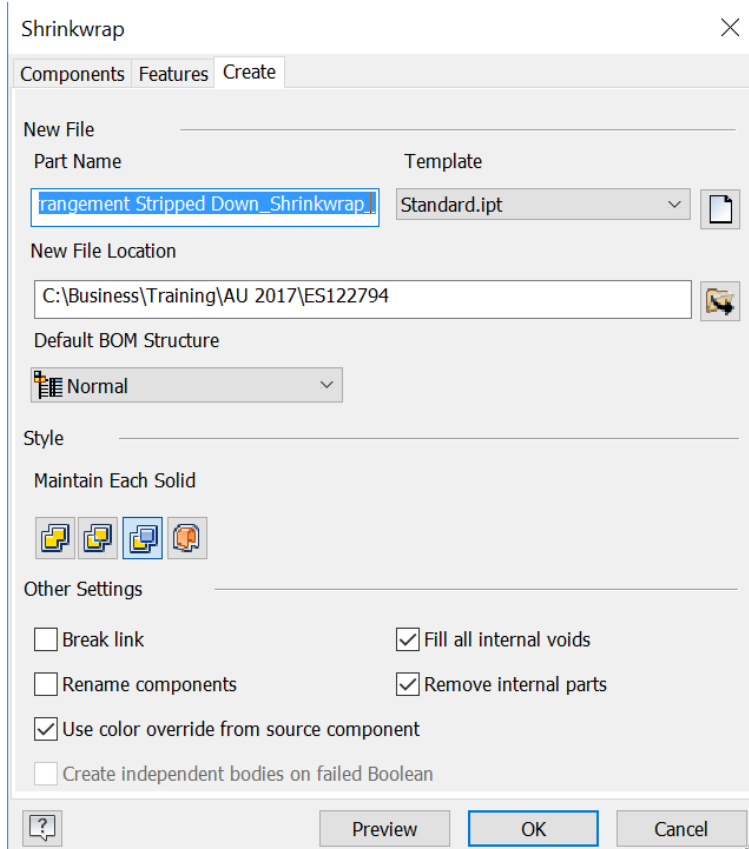
5. This will open the **Shrinkwrap** dialog, which is used to reduce the detail level of an imported or Inventor model. The dialog includes, three tabs:
 - a. **Components** – sets the default **representation**, **removes parts**, and defines what components are to be **included**:



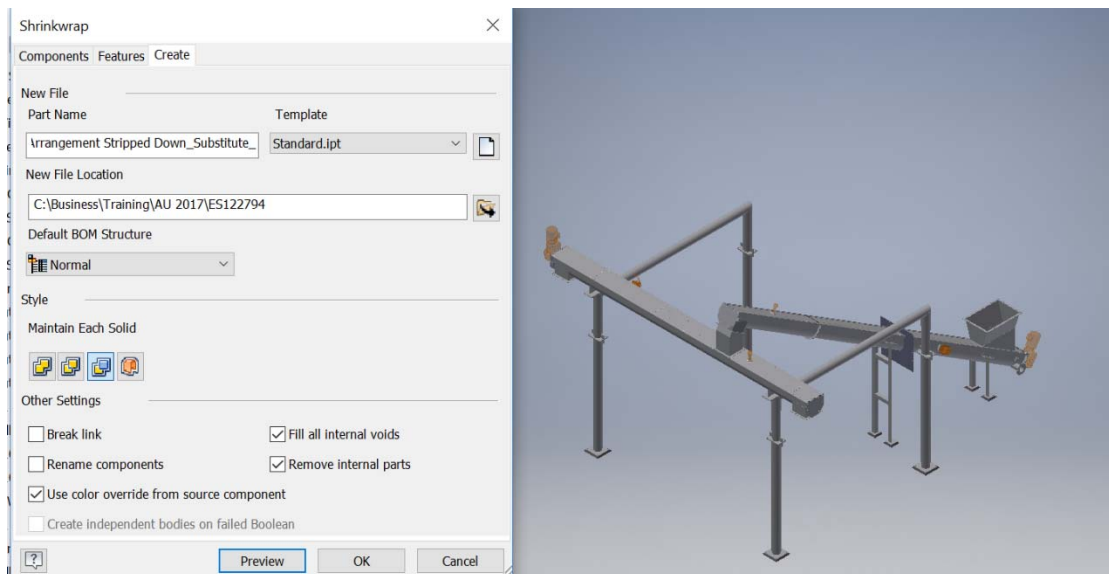
- b. **Features** – removes **holes, pockets, fillets** and **chamfers** that can cause a part to fail on import into Revit:



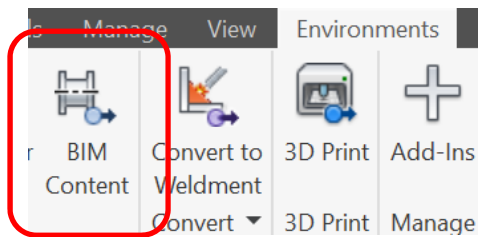
- c. And **Create** – defines the **file name** and **location**; determines how the **style** is defined, including **single body**, **separate solid bodies** and more; other settings for **color overrides**, **filling internal voids** and **removing internal parts**:



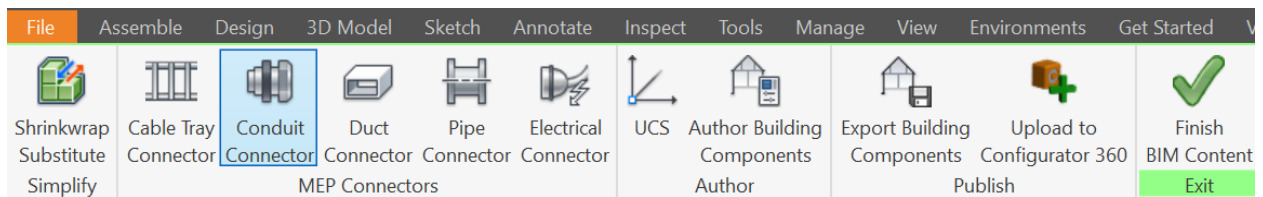
- Click **Preview** to get an idea of how the part will look:



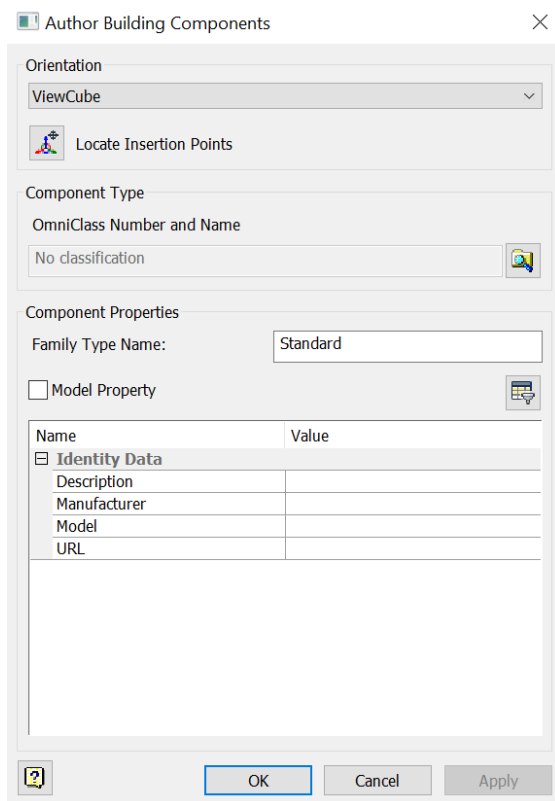
- Selecting **OK** will run these tools at once, and reduce the level of detail in the model. To **export** the model, begin by selecting the **BIM Content** tool on the **Environments** tab:



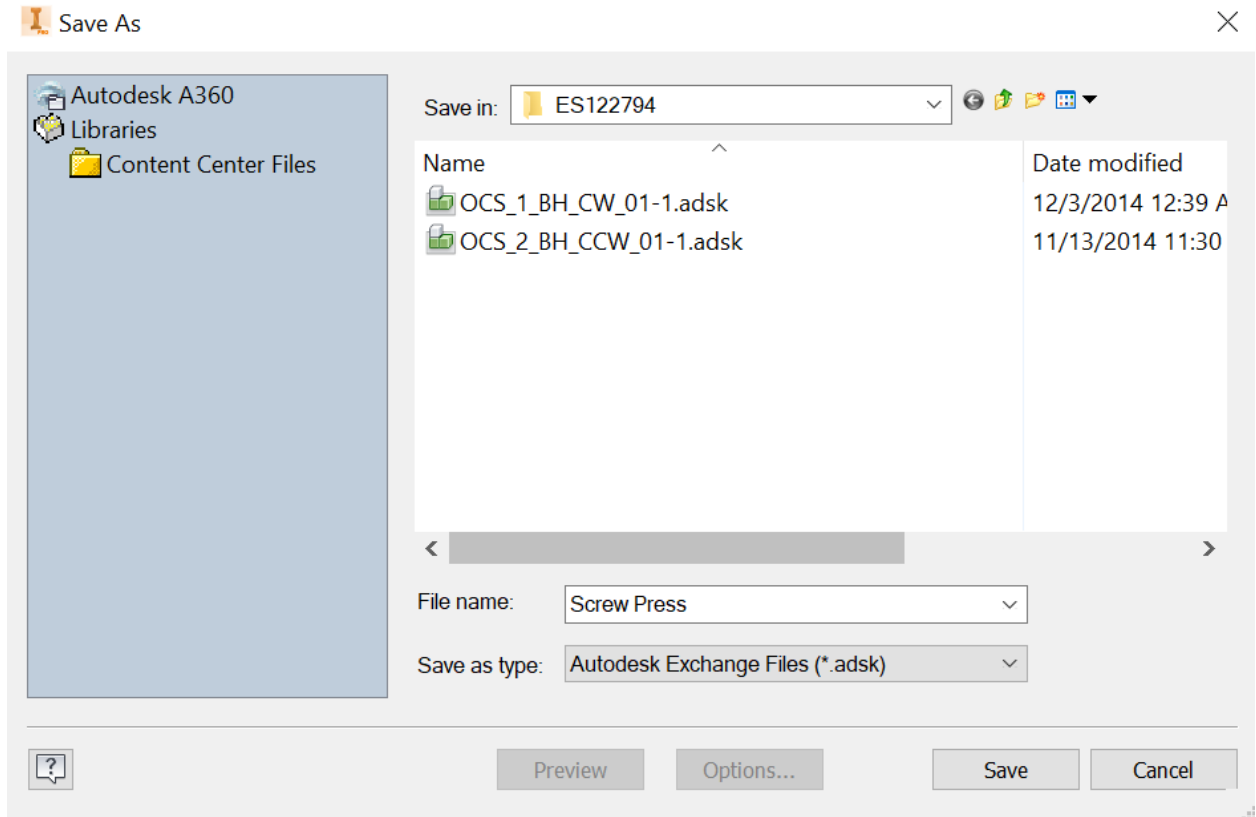
8. The **BIM Content** tab appears. You can run the **shrinkwrap substitute** feature prior to exporting the model (which creates a duplicate part), add **connectors** as needed (we do this in Revit instead) and set the default **UCS** for the part:



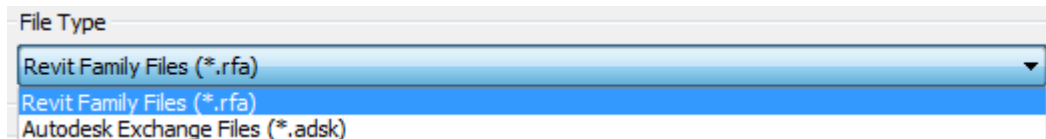
9. Select the **Author Building Components** tool to set the default **orientation**, **Omniclass properties** and default **Family type name**:



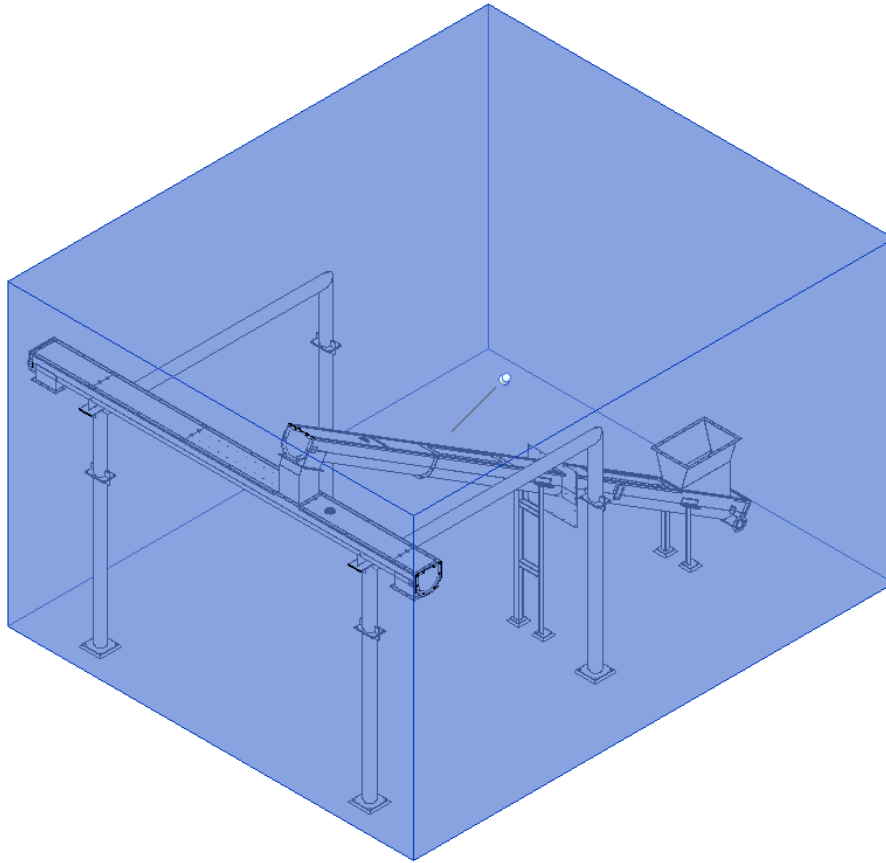
10. Select **Export Building Components**. The Save As dialog appears:



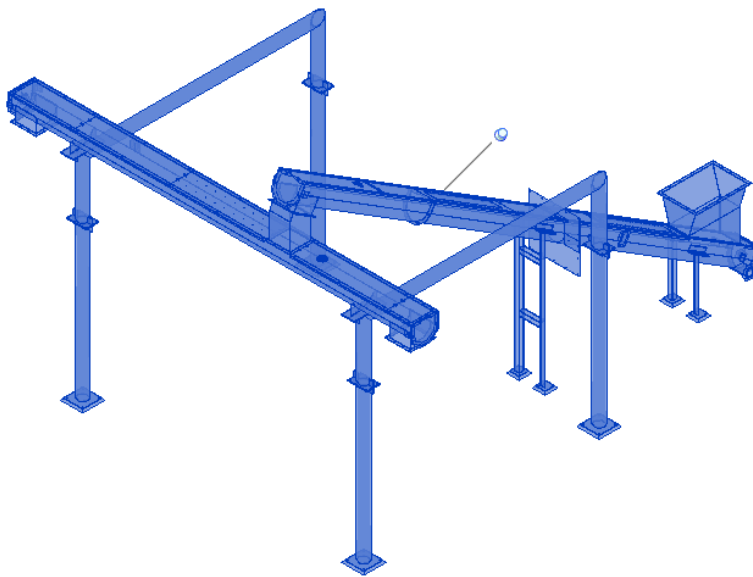
This dialog lets you pick between **RFA** or **ADSK** file formats. A native RFA file will include **individual solids** in a Revit family, while an ADSK file will include a **single 3D model** and **views** based on orientation (similar to the AutoCAD Region command). If you have any problems exporting to an RFA, you can usually successfully export to IFC or ADSK, which is what is used in this example:



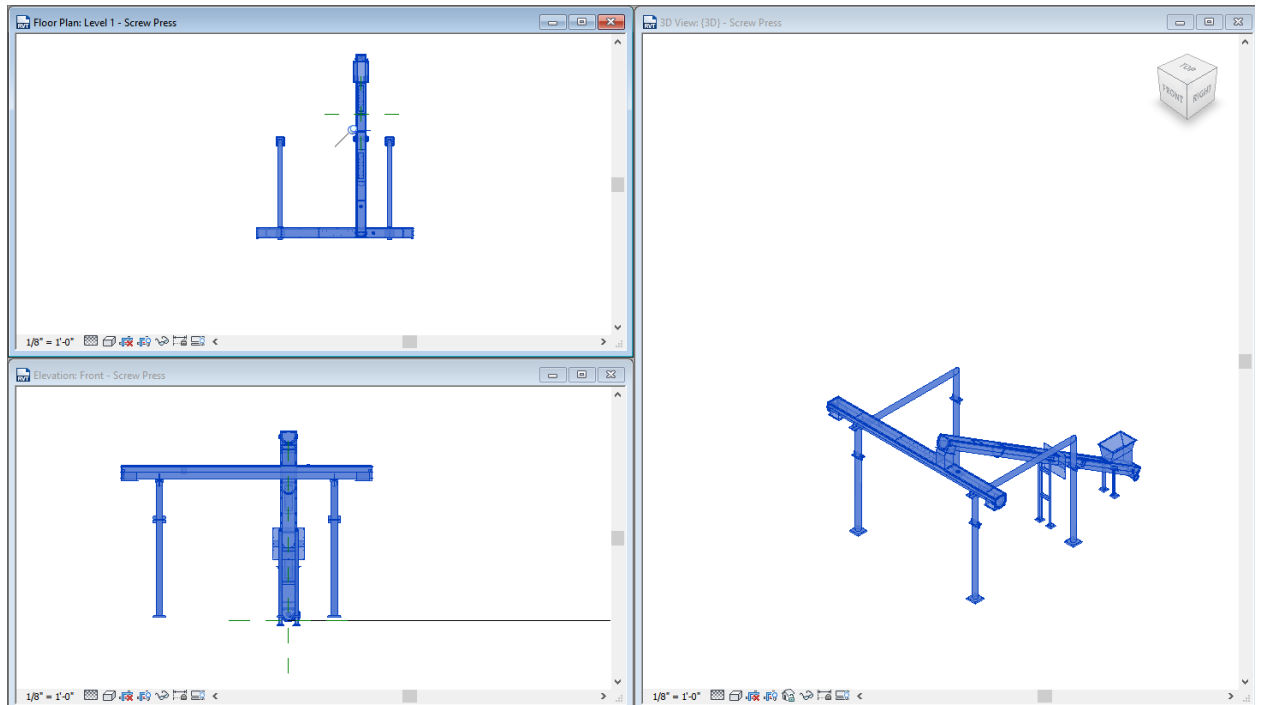
11. Select **Save**, and save the file. **Finish BIM Exchange** will close the tool. You can open the ADSK file directly in Revit, as it is treated similar to a family. When the file is opened, there will be two parts – the actual 3D model, and the bounding box that includes all of the face representations of the object:



12. Select the **outer box**, and **unpin** it. Once the pin is removed, you can delete this part, if you only want the 3D representation of the part. After deleting it, the 3D model remains:



13. Check the **plan** and **elevation** views to make sure the part **aligns** with **reference planes**:



14. **Unpin** the part and move it as needed, using the **align** and **move** tools, to place the object at the best insertion point:

Once the part is at the correct location, you can add **connectors**, set the family **category**, add **parameters** and **materials**. The part is now ready to use in your project.

Even with conversion issues, it could be better to start from a well-defined part from a vendor, than to try to model something for scratch. These packages give you a variety of options, from *RFA* and *ADSK* files to *SAT* and 3D *DWG* models. The preferred format for conversion using Inventor is, of course, The advantage of *RFA* and *ADSK* over *SAT* and *DWG* is the **native file format**, but *SAT* and *DWG* can always be imported as CAD files in an *RFA*, and connectors or other Revit-based solids can be added to the models. Whatever you choose, these tools help you create the level of detail you need in your design.

Questions on Conversions

Did the vendor include a detailed model, and include lot of informational parameters with their family?

This is another side effect of working with content from aggregators or content developers. One weakness of the industry is that we have all kinds of standards for layer names, model development and more. We don't have a standard for data formats, but bSa (*building Software alliance*) is leading the initiative to do this. Data in Revit is based on a specific **GUID** number that is associated with parameters, families, and system content.

We use a process called “Gannettizing”, which is required reading from any of our internal content developers or project BIM leads. They know to strip out any parameters that aren't going to be related to any of the schedules we use, and put in the right ones, in the right categories, when they get the part – and **before** it gets placed in the model. This includes these steps:

Using Non-RFA/ADSK Content

- Use **Inventor** to edit supplied models that are not in *ADSK/RFA* format – prefer **IAM** or **STP** files as the best conversion results
- Remove internal parts, high detail items (such as bolts with threads)
- Use **Recognize Revit Features** to discover what can be used/edited natively in Revit
- Use **Simplify** tools to remove additional details, fill voids and define envelopes.
- Use **BIM Exchange** to save as *ADSK* or *RFA*
- Add Connectors/Corporate Standard Shared Parameters and Subcategories in family file
- Set classification/OmniClass numbers
- *Using Revit Content*
 - Add MEP connectors
 - Remove non-standard parameters from families
 - Add/Associate standard shared parameters based on default schedules

- Set classification/OmniClass numbers
- Limit text-based versions to specific model(s) as need for design

Do you have the pertinent data that's associated with the equipment?

Once you've gotten the model, this is where the significant difference in a traditional project differs from a BIM project. Since you're used to dealing with 2D, the normal procedure is to take a block and drop it in a plan, and consider yourself finished. But in the BIM world, you're just getting started.

The part needs to include as much data as possible that is provided by the vendor. When relevant, the data is associated with electrical, duct and piping connections that are added to the model. Some of the data associated with mechanical equipment we like to know about include:

- Voltage/Number of Poles/Phase
- Load/Horsepower
- Flow Rates
- Model Number
- Weight
- Connection Size
- Clearance Requirements

Once the equipment is loaded into the model, it can be used to develop layouts of systems families, and continue to act as a repository of data. This information can be associated with schedules, exported to databases or spreadsheets, and used to help size duct, pipe and circuits. Now, you're ready to take a deeper look at how BIM changes the design workflow and process.

Revit versus CAD – CAGE MATCH!!

Once you've got an idea of the service and process equipment needed for the design, this is the time where the traditional design tasks start to really differentiate themselves, and cause the most disruption. This is where the fun begins – and project managers cringe. We have a standing set of orders that we give to our team leaders and managers:

Forget everything you know about how to put a project together in CAD.

This strikes fear into most folks, but it's really not that bad. We say this to get them to understand that CAD techniques don't always apply the same way when using tools such as Revit to work on a project. So, we came up with a checklist, and make sure that every PM and engineer understands what they need to be looking for. Each of these tasks are broken down by phase, with a couple of caveats:

Plan on spending more time in the schematic phase and less time in the document phase.

Break your work down into the four-step process – select and add equipment (targets and sources) define systems, create connecting geometry and annotate.

This helps to correctly align tasks with the corresponding phase. Here's the breakdown of the specific task changes.

Pre-design/Schematic Phase

When a project starts, there are several items that have to be addressed before the engineer can even get started. The architects are effected the most – while the design doesn't have to be complete, the model has to be well defined enough that several other tasks can be completed. These are the main items we look for:

For the **architect**:

- Set the site and orientation!
- Perform massing studies for solar/shadow impact, airflow, etc.
- Define bounding elements and datum levels in the arch model – can be generic (LOD 100-200) until materials are selected – includes floors, slabs and roofs
- Add room objects to arch model, space and zone objects to MEP model – sync room and space data

For the **MEP/Process engineer**:

- Develop and refine schematic layouts – hydraulic profile, process schematic
- Best time to perform analytical studies – energy, airflow (CFD), lighting, LEED, etc.
- Don't over-detail or over-model!
- Select BOD equipment as early as possible based on programming/criteria

- Locate major equipment, targets/sources and define preliminary systems – HVAC, piping, electrical, plumbing, process

Design Development Phase

Once the early design tasks are complete, it's time to move to the next phase and refine the design. The design development phase is just that – the time to flesh out how the systems work, adding structural components, add detail as needed to supplement the systems, and start to coordinate the data between the disciplines. In this phase, the engineering team needs to make sure their model is developed to the right LOD, so they can complete these tasks:

For the Architectural/Interior/Industrial Designer:

- Add more detail to bounding elements – wall, door, window types, etc. based on analysis results
- Add owner required equipment and built-in components – casework, furniture, industrial, etc.

For the MEP/Process Designer:

- Develop and refine power and piping/plumbing riser diagrams, initial P&ID's
- Refine Equipment placement, locations, parameters
- Associate equipment with rooms
- Add connecting geometry for MEP elements – duct, piping, conduit, cable tray
- Add power/air/fluid source connectors for industrial/architectural components, not in MEP model
- Coordinate data between disciplines for MEP requirements
- Associate and confirm loads with equipment (electrical, HVAC, fluid)

For the Structural Designer:

- Develop/Refine structural model to show minimum of primary concrete/steel/etc. materials
- Coordinate openings/penetrations for major components

Construction Document Phase

Wrapping up the design occurs in the last phase, and this is where many traditional tasks are replaced. Generating sections, elevations and schedules are redundant, since program is controlling what's visible in each area as the project has progressed. But there's more going on in the project than what you see in the paper product. In this phase, the engineering team needs to understand what tasks are needed to validate the design, by following these steps:

- Complete model layouts with accessories, supports, etc.

- Track and quantify:
 - Power loads
 - HVAC loads
 - Lighting Loads
- Associate by Hyperlink
 - Reports
 - Specs
- Compete schedules with additional data and parameters
- Add 2D details where 3D isometric, section, elevation and enlarged plan views don't cover it
- Complete view annotation with labels based on information derived from parameters in the objects, adding text and dimensions where needed
- Complete constructability reviews using interference detection tools built into modeling tools

Beyond BIM

Most design firms approach CAD as though it has a static stop point. You produce the drawings, print to PDF, and put the work out to BIM, leaving it to the contractor to detect errors, and work out conditions in the field. When correctly defined, the project models have an expanded shelf life that 2D drawings, spreadsheets, documents and paper just can't match. The model is digital record of the design process, but extends to many areas beyond these items.

Initially, working on a BIM project is actually an investment. The first few jobs, you're going to be hashing out content, standards, data storage and many other items that aren't part of a CAD job. In order to make sure you're pointing in the right direction, you almost need to back up to the beginning. At the start of the job, you have design around the concept that the model will ALWAYS extend beyond the end of design, and be used for:

- Return Work - Renovations
- Construction Management
- Asset Management
- Future Studies
- Municipal Integration

Another aspect that can really benefit the firm is using the model for marketing. Renderings and images, as well as animations, can be used in presentations to help explain how a system works, or how a comparable project would be designed, in much greater detail.

The construction industry has been a large driver of BIM in projects, as this gives the contractor the clearest view possible of how everything fits together. Models can be used for coordination,

timeline simulation, bill of materials and estimating. As an asset management tool, the model's information can be linked to asset and facility management software, including:

- Single Source
- OMMS
- Lifecycle Management
- Space Planning
- Ownership

Other uses for the model include the ability to conduct future studies. The model can be edited and defined to reflect as-built conditions, which can then be used to review impacts on future and surrounding projects. This would include urban planning, solar/shadow studies, and transportation/movement impacts.

Lastly, the model can be used as an integration tool, to provide state, local and federal government entities with more accurate and up to date information. Utilities including electrical, water, wastewater and water resource projects can gather data in regard to the buildings for power, water usage and sewage needs. Transportation and traffic management facilities can be modeled, and used in a variety of projects, including maintenance, toll collection or more. And when created in conjunction with a site, the model is highly valuable to GIS based applications, allowing the urban planner with a more detailed look that just the shell.

Enter the Contractor – Fabrication in Revit

On the design side, we've always dealt with basic representations of objects, limiting the detail in our construction documents. Means and methods dictate how common parts are installed, so the engineer typically doesn't provide the complete level of detail needed to create the project down to the last nail, screw and bolt. As an industry, that's where design stops, and the fabrication of the parts begins. Normally handled by the contractor, Revit now includes fabrication tools for MEP that can add that higher level of detail.

About Fabrication MEP

In order to understand where the design level content ends and the fabrication content begins, you need to understand the tools. A fabrication part is a higher level of development, typically LOD 400, and was developed from the original CADmep, ESTmep and CAMDuct products that originally ran on top of AutoCAD.

Fabrication tools are designed to allow a user to take an existing LOD 300 Revit model, and convert the native Revit objects to LOD 400 fabrication content. A user can also model the piping and ductwork using point-to-point layout tools.

Fabrication models required a fabrication **configuration** and **services**, which are loaded into a project. The **configuration** provides the content – for example, when the settings are selected, you can choose between an **imperial** or **metric** library of predefined parts, based on materials:

Fabrication Settings

Fabrication configuration

Connection Indicators

Fabrication configurations

Revit MEP Imperial Content V2.1

Revit MEP Metric Content and Database

Fabrication profiles

Global

Fabrication services

Reload Configuration

Unloaded services cannot be added until the configuration has been reloaded.

Unloaded services

Ductwork: (1000PA)
Ductwork: (1500PA)
Ductwork: (2500PA)
Ductwork: (250PA)
Ductwork: (750PA)
Ductwork: Ductboard
Ductwork: Flue Duct - MultiShape
Electrical: Ladder
Electrical: Wire Basket
Electrical: Wireway
Piping: Carbon Press Fittings
Piping: Copper Press Fit
Piping: Copper Soldered
Piping: DWV Soldered
Piping: No Hub
Piping: No Hub Below Ground
Piping: Polybutylene Electro Fusion
Piping: Polypropylene Socket Fusion
Piping: Press FitXGrooved
Piping: WeldedXPress Fit
Piping: WeldedXSocketed
Piping: WeldedXThreaded

Add -->
<-- Remove

Loaded services

Ductwork: (500PA)
Electrical: Busway
Piping: ABS
Piping: Copper Brazed
Piping: PVC-C 40
Piping: ThreadedXGrooved

[Learn how to set fabrication configuration and services](#)

OK

Cancel

Once the services are loaded into a project, the **MEP Fabrication Parts** palette will appear. Any items you have loaded can be selected from the **drop down** at the top of the palette:


MEP Fabrication Parts

Service: Piping: Potable Water

Group: Piping: DWV PVC 40

Piping: Potable Water

☐ Piping: Service Weight

 Piping: SolderedXGrooved

Piping: ThreadedXGrooved


































Type L Piping: WeldedXSocketed

After selecting the **service**, the available **fittings** associated with the service are displayed:

MEP Fabrication Parts

Service: Piping: DWV PVC 40

Group: Fittings

						
PVC Sch 40 DWV Pipe	Fourth Bend HubxHub	Long Sweep Fourth Bend	Fourth Bend SpgxHub	LongSweepFour HxSpg	Closet Bend Red HxH	Eighth Bend HubxHub
						
Eighth Bend SpgxHub	Sixteenth Bend HubxHub	Sixteenth Bend SpgxHub	Coupling HubxHub	Sanitary Tee HxHxH	Sanitary Tee Red HxHxH	Sanitary Tee SpgxHxH
						
Sanitary Tee Red SpgxHxH	Combination Wye	Red Comb Wye	45 Wye HxHxH	45 Reducing Wye HxHxH	Street Wye SpgxHxH	Street Wye Red SpgxHxH
						
Double San Tee	Double Red San Tee	DblFixtureFitting HxHxH	Dbl Comb Wye Eight Bend Size	Double Wye HxHxH	Red Double Wye HxHxH	Double Bend HxHxH
						
P Trap HxH	Flush Bushing SpgxHub	Cleanout Adapter	Cap Socket	Forth Bend Low Heel Inlet		

Settings...

Each **service** will have additional **groups**, for hangers, joints and valves in specific services:

MEP Fabrication Parts

Service: Piping: DWV PVC 40

Group: Fittings

Fittings

Joints


Hangers

As you change the **group**, the available parts are listed:


MEP Fabrication Parts

Service: Piping: DWV PVC 40

Group: Hangers



Clevis Hanger
Blk










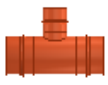






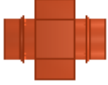


Riser Clamp

When you change **service**, the new **group** and associated **fittings** appear:

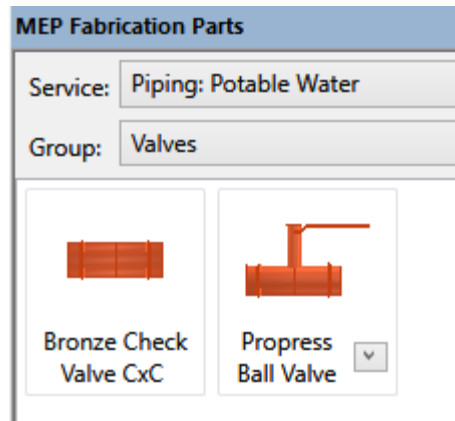
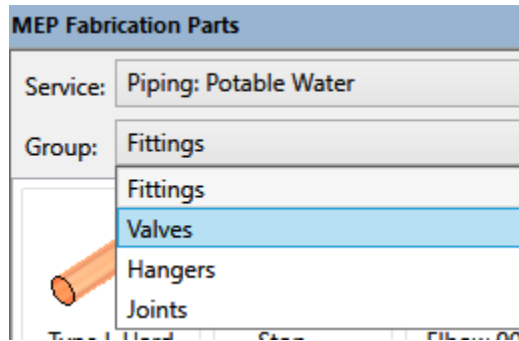
MEP Fabrication Parts [X]

Service: Piping: Potable Water

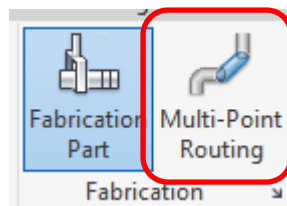
Group: Fittings

 Type L Hard Copper	 Stop Coupling	 Elbow 90 Close	 Elbow 45 PxP	 Reducer FTGxP	 Reducer PxP	 Tee PxPxP
 Venturi Tee PxPxP	 Cross Over PxP	 Adapter Flange	 Adapter PxMPT	 Adapter PxFPT	 Elbow Drop 90 PxFPT	 Manifold 3- Outlet PxFTGxP
 Union PxP	 Di-Electric	 Cap P				

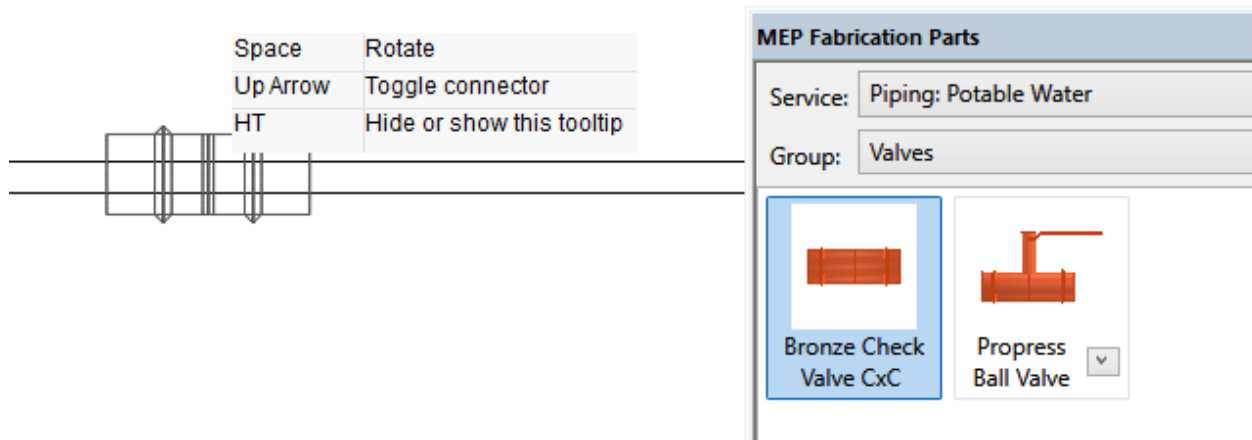
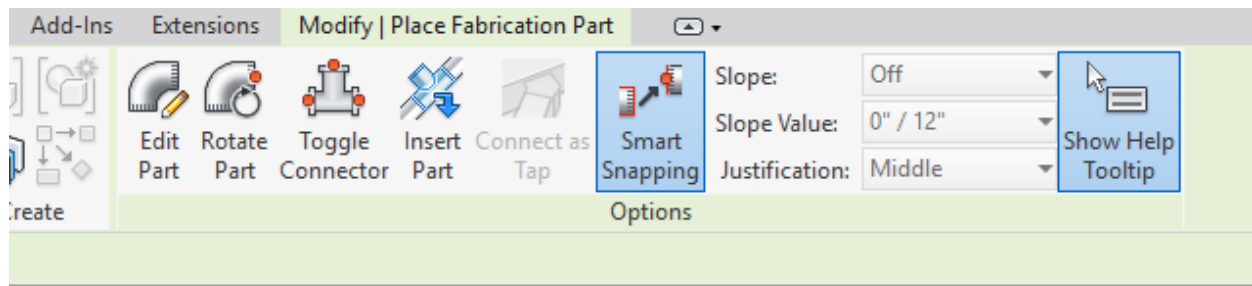
If **valves** are available, then you can add them directly from the dialog:



Once the services are added, you can use the **multi-point routing** tool to create a pipe run:



You can also **double click** a part in the palette, and place the object manually:



Once the fabrication parts are placed, they represent a higher level of detail than most of the out of the box Revit piping content.

When to Use Fabrication?

This portion of the class is not intended to be a detailed training guide for producing fabrication content in a project. It's important for the design team to know when to use these tools, and the limitations/advantages for the team for each element type.

The considerations below are based on the objectives of the content:

Use Revit Piping:

- When limited LOD of 350 or less is required, and a placeholder representation is adequate for design intent
- When piping or duct system data is required for sizing, schedules, flow data and other design specific tools related to the system
- When pipe routing needs to be system based
- When the services for the specific pipe type are not developed for the fabrication tools – project must allow time for the content to be developed
- When the BIM management team does not have the training/expertise to develop custom fabrication services and groups

- When the project does not require as-built conditions that are modeled to LOD 400 or higher in the Revit model

Use Fabrication Piping:

- When the contract is design-build, and LOD 400 or higher is required
- When the contractor is providing the BIM model
- Where system information is not relevant to the contract deliverable
- When the layouts are going to be used by the contractor for fabrication (shop or field) – note that design piping can be converted to fabrication piping by the Fabrication MEP tools, saving time for both the designer and contractor

BONUS SECTION: Disruptive Changes – Revit Tools that Make a Difference

So far, you've learned about how to prepare and plan for a BIM project, how to change engineering tasks that are influenced by the BIM process, and what tasks get changed in a project timeline by using BIM software. While these topics are not part of our objectives, I've left them in here to offer additional insight into tried and true tools that can make a difference in your project. Here, we look at some of the key areas where BIM makes a large impression, including two of the more disruptive tools in the Revit software – the views and schedules.

The Best Point of View

As a project manager, architect or engineer, starting a project means planning for the deliverables. The common term used to describe this is defining the “cartoon set”, which identifies the sheets, and the views that will be used to explain the design to the contractor. In CAD logic, this means deciding what plan, section, elevation, detail and schedule views are used.

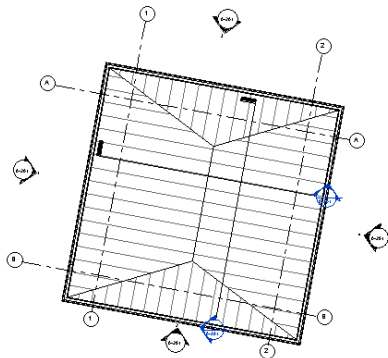
For the technician to complete this set, you gain productivity by repeating how you create these views in a project. But this can be complicated if the project includes several buildings or structures, that don't line up nice and pretty at right angles. Another view that's becoming more common is the 3D view of building. There may be a case where a cutaway view helps explain what's happening, and provide clarity. Let's look at a couple of view tips first.

Rotating Plan Views

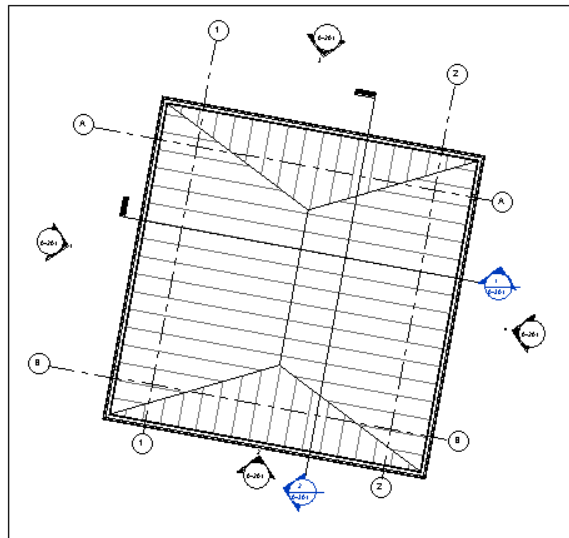
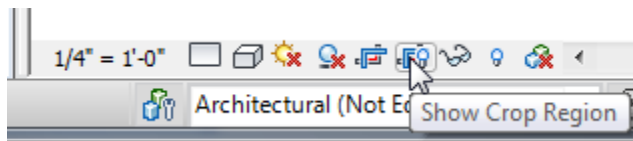
There are two methods for approaching the creation of model. The traditional documentation method tells you to start laying out a building from a known point. In AutoCAD parlance, this is commonly known as 0,0, or the drawing base point. This method has been used for years, since it helps you line up 2D drawings, so they can be stacked on top of each other and used for coordination and more.

You can do the same thing in Revit, but in most cases, it's better to align the building with the site. This is what causes architectural and MEP CAD users fits, since this usually means something's going to be rotated – a north arrow, a floor plan, or a site plan. In Revit, it's fairly simple.

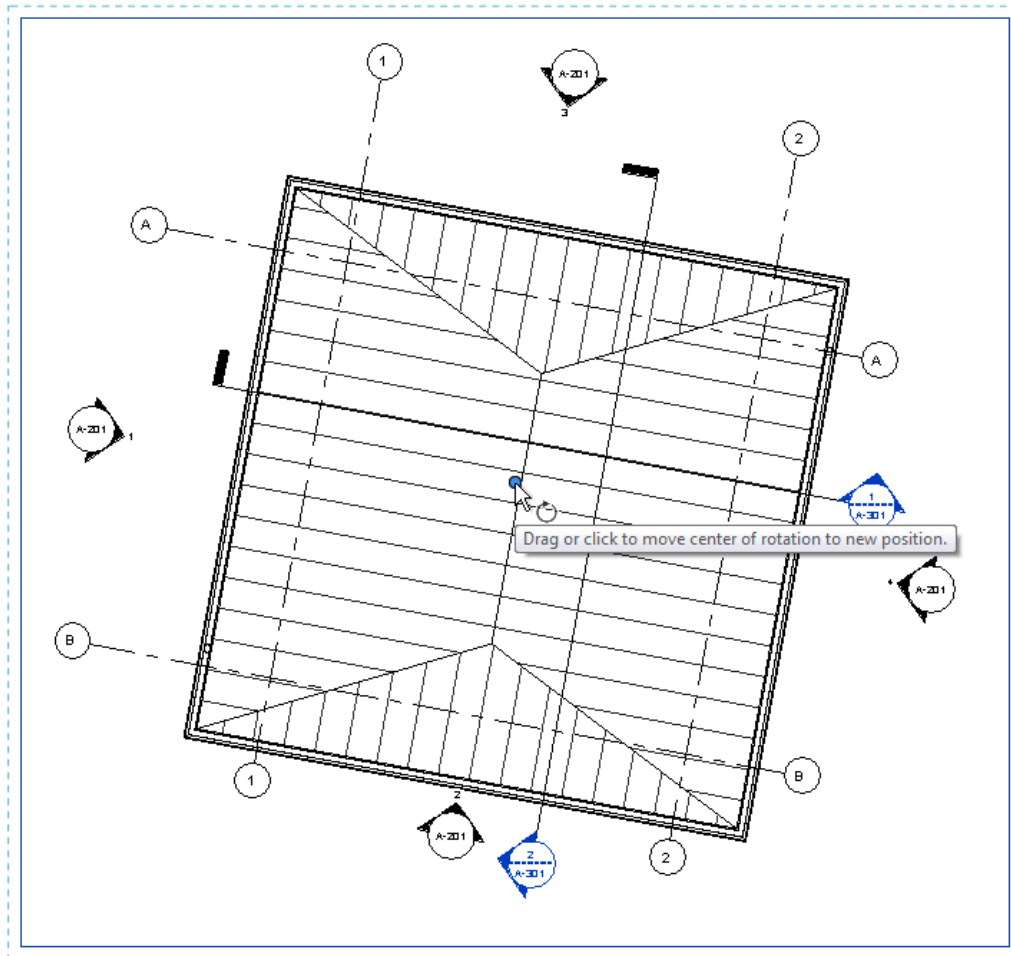
1. Open a plan view that is oriented to the site, where the site is not rotated, and the building is laid out at real world coordinates and orientation.



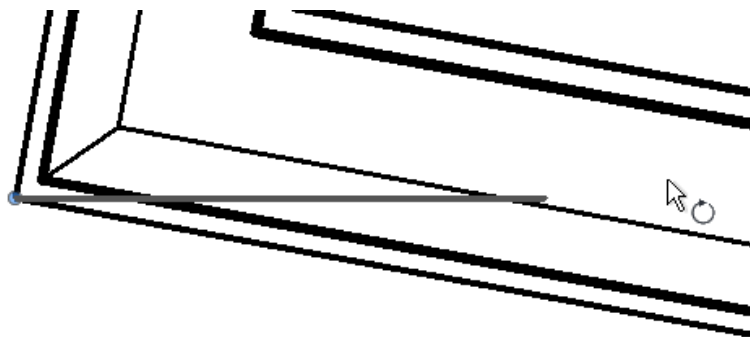
2. Toggle on the “**Show Crop Region**” and adjust the view crop as necessary.



3. Select the **Crop Region** box, then select the **Rotate** tool. Move your mouse pointer over the rotation **center** dot: hold your left mouse key down and move the rotation **center** dot to a **corner** point on your structure.

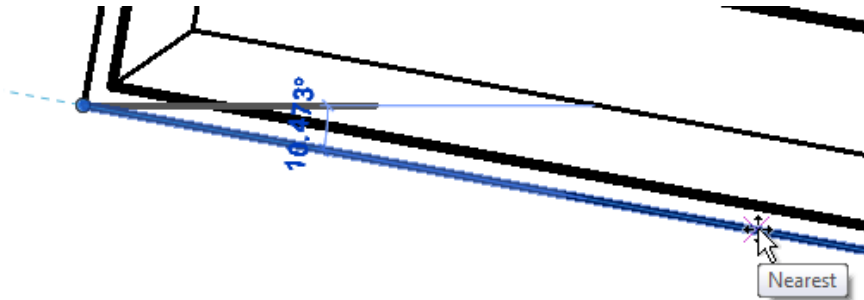


4. Zoom in to make sure you are on a corner point, and then set the rotation line **horizontal**.

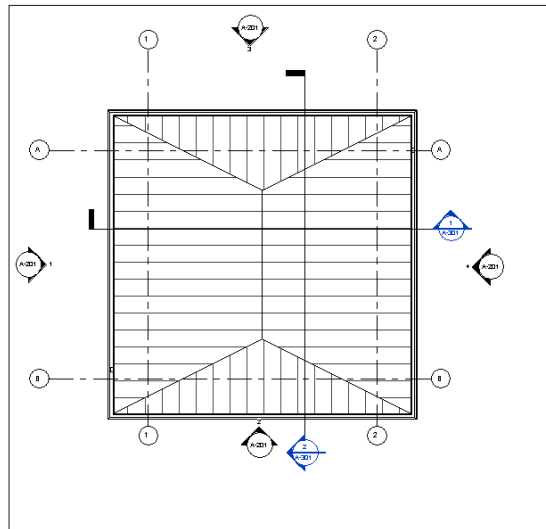


5. Click your mouse to start the rotation and move your mouse to the **line of the structure your rotation point is snapped to**. Click your mouse button to

complete the rotation, and your structure should now be a normal x-y, orthographic orientation.



6. The view is now “flat”, or orthographically straight.

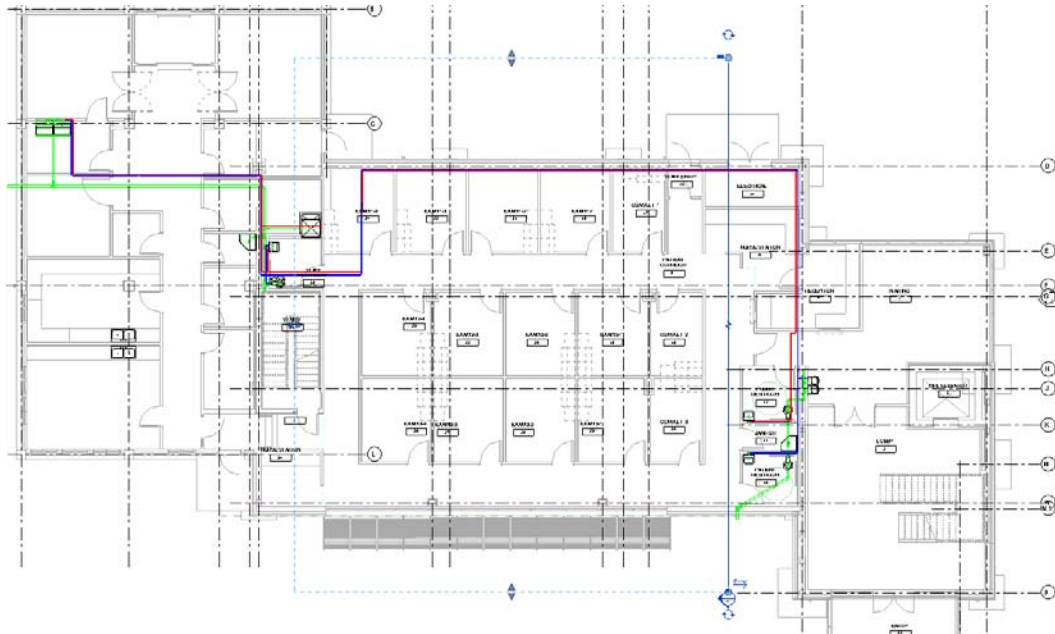


Why do this? If you're adding linear components, such as a duct or pipe, it's easier to rotate the view, and then work in that view, to add these components. This is especially true if you are adding components at right angles. The Revit system tools for duct, pipe, conduit and cable tray work best when orthographically defined. Any annotations placed in the view will also be correctly defined, and easily placed. Do your layout work in these views, and then create an overall view after you've added the items specific to the structure or building.

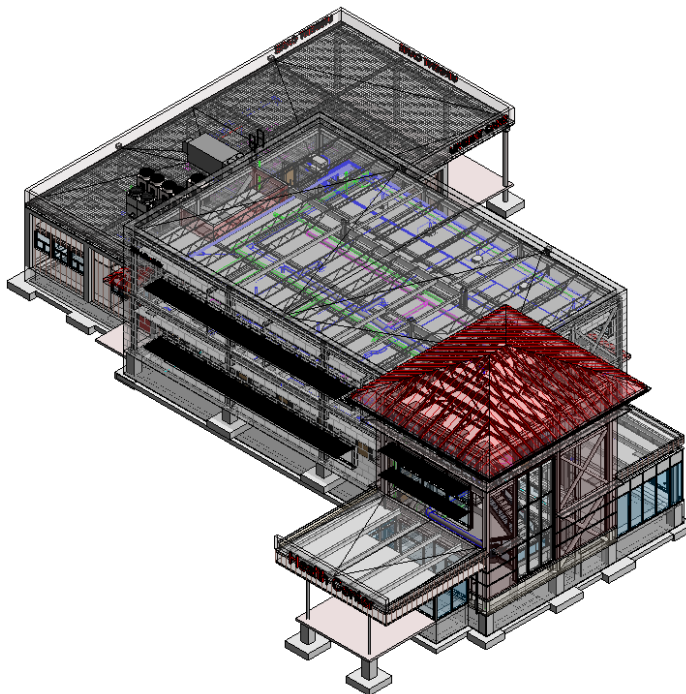
Creating a Cropped 3D View

Sometimes it's easier to trim down a model and look at a specific area, to understand how everything is going to fit into a room. You can leverage the section tool to define cropped 3D views, so let's take a quick look at how to define this type of view.

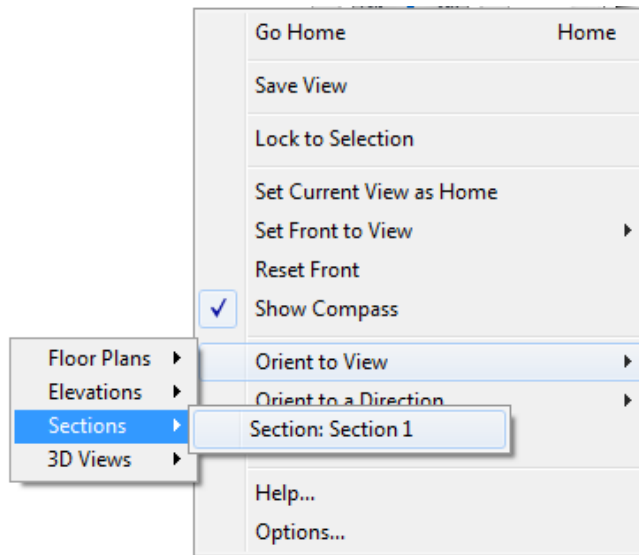
1. From a plan view, add a **section**:



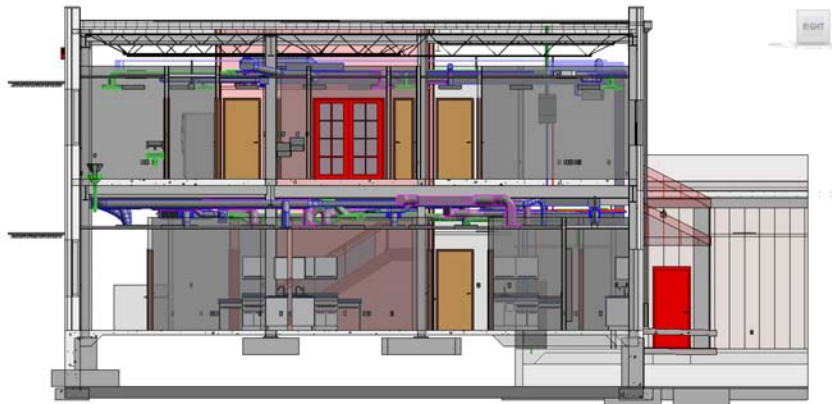
2. Stretch the **section box** to cover the area you want to show in the model. Once the box is defined, change to a **3D view**:



3. In this view, the **architectural features** have already been set to have a high transparency level in **Visibility Graphics**. Right click on the view cube, and select the **Orient to View > Sections > Section 1** that was just defined:

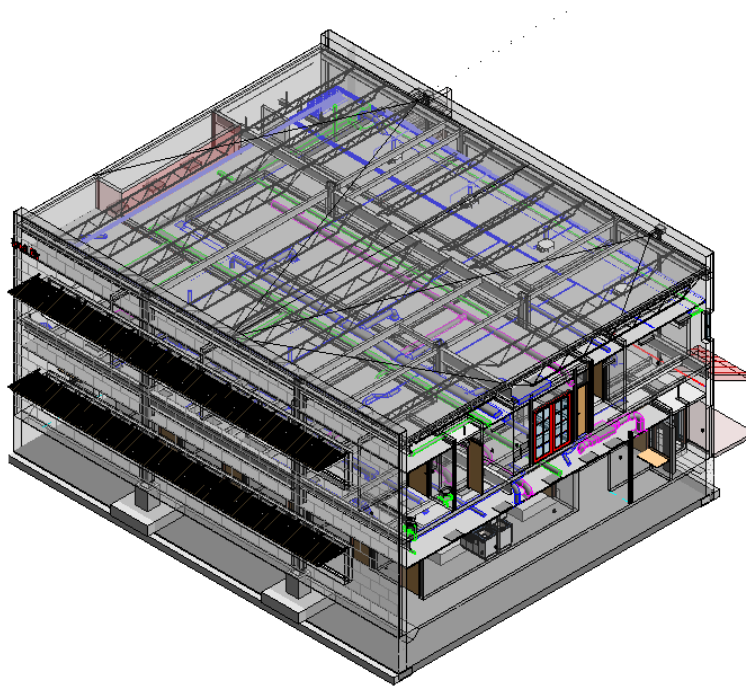


4. The model will automatically crop itself and rotate to the view direction of the section:

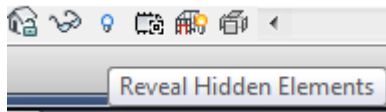


5. If you're paying attention, see if you can find where there's an error in the architectural model.

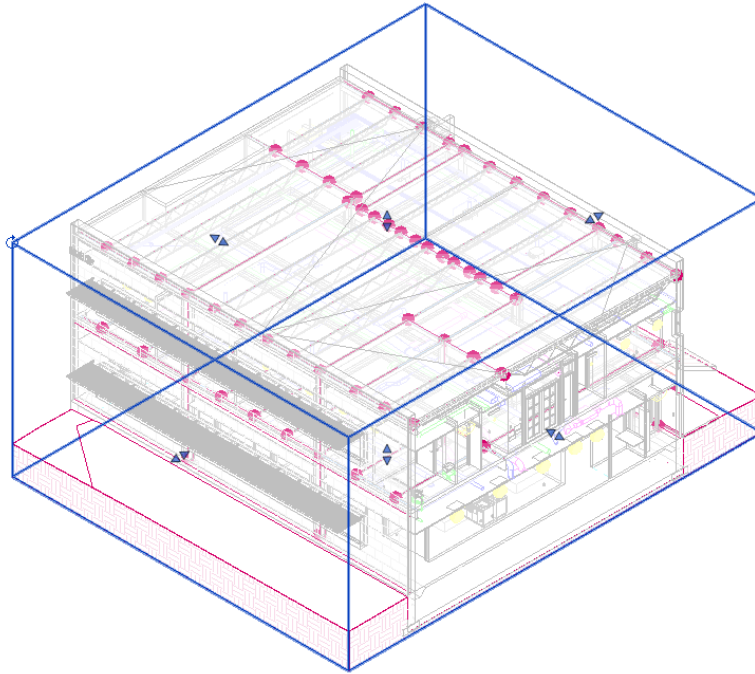
Once the view is cropped, you can use the **View Cube** to change the view direction:



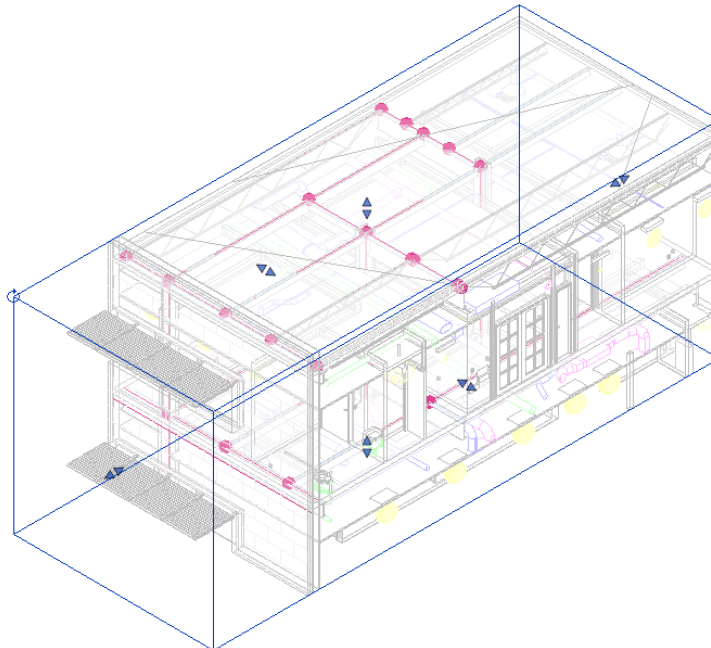
7. Here's a neat trick – at the bottom of the view, select the **Reveal Hidden Elements** tool:



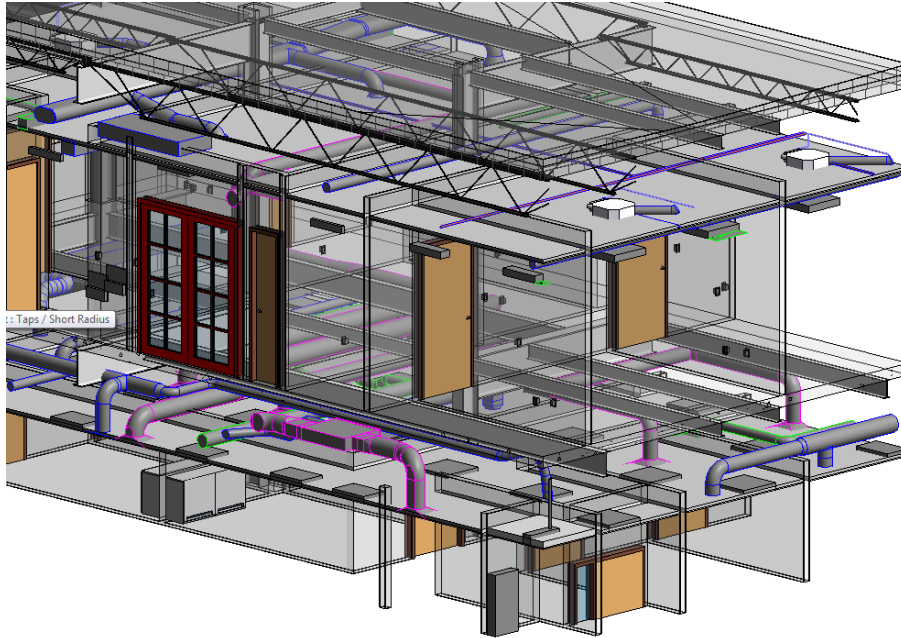
8. You're looking for the **section box** – pick it and you'll see **grips** on each of the surfaces:



9. The grips allow you to change the **cropped area** of the section box, so you can reduce or enlarge it as needed:



10. Turn off the **Reveal Hidden elements** tool, and orbit around to another side. Notice how it's easier to locate a design flaw:



11. **The error is obvious - either the ceiling needs to be lowered, or the lights need to be raised.**

In this case, we used this tool in a client meeting to help cover how the design worked, and locate the problem that could have led to a potential change order. Leveraging the views in a non-traditional fashion improved the communication between the design team members as well as the client.

Getting Schedules to Work for Your Team

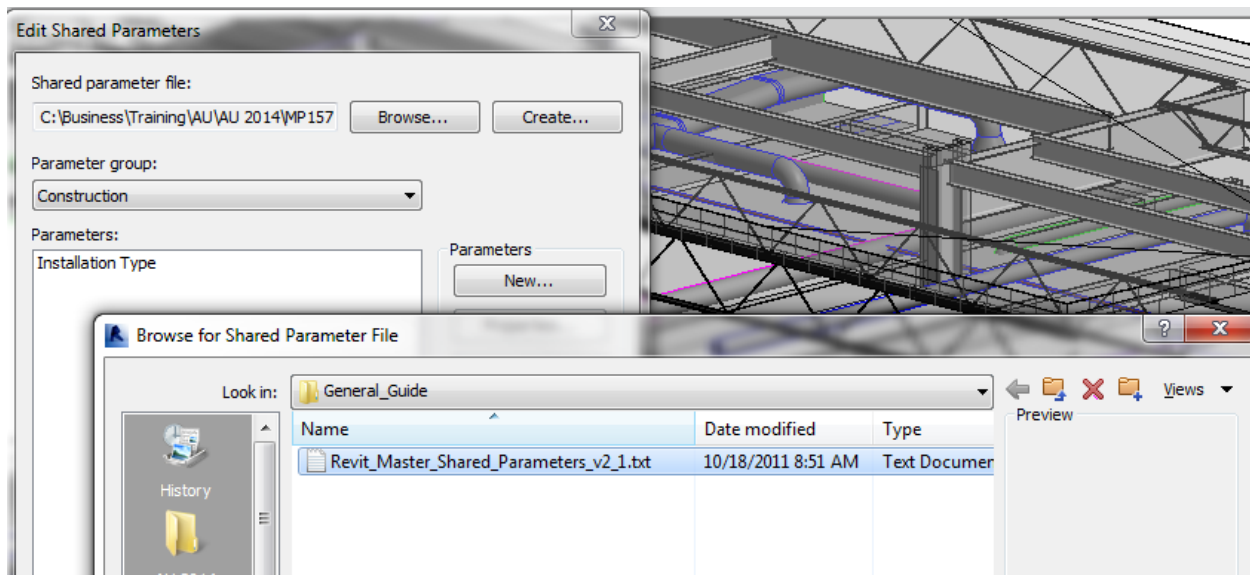
The last item that you need to focus on is the use of scheduling tools in Revit. Most engineers and some architects depend heavily on Excel files or CAD tables (and in some cases, still use lines and text) to define room, door, equipment and electrical schedules. The problem with this method is that the data is disconnected from the physical representations of the design. For example, if a door size changes, you want the schedule to update automatically – and that won't happen when you keep these items separate. For schedules to work, you must edit a couple of items – shared parameters and view templates.

Defining Scheduling Data the Right Way

For any data to be used in a **schedule** and a **tag**, it must be defined as a **shared parameter**. Autodesk provided a starter version several releases ago, and it's included with this class (it will be available as a download after the event at au.autodesk.com, search for this class and look for the ZIP file downloads). This file is named:

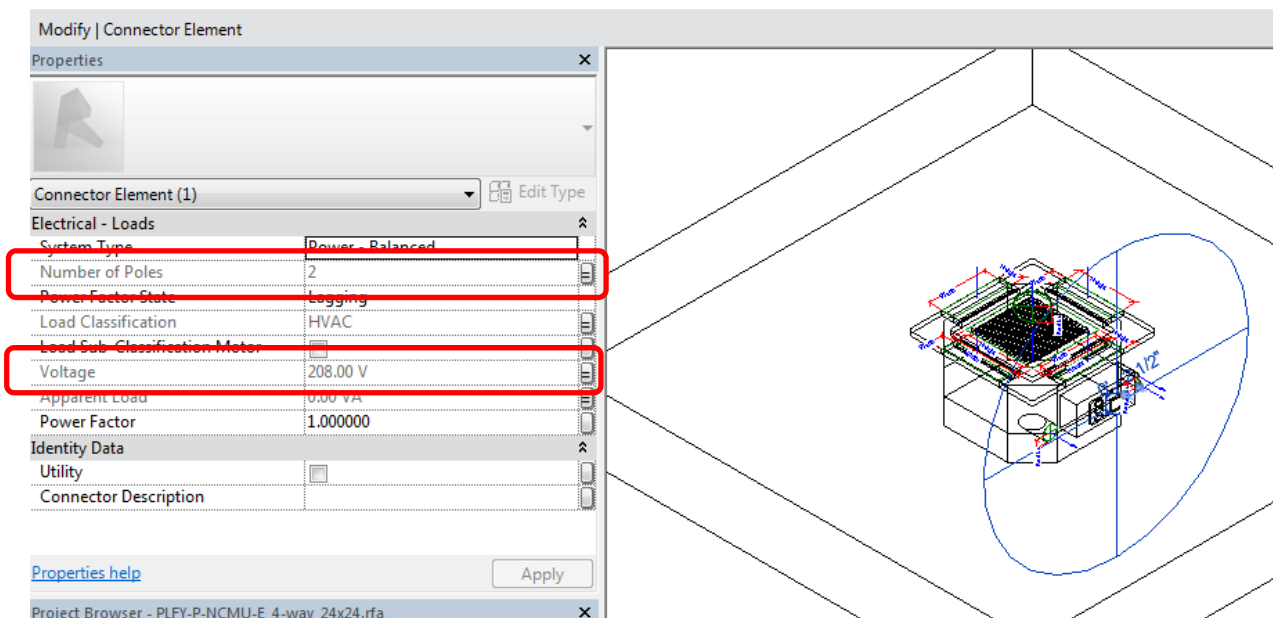
Revit_Master_Shared_Parameters_v2_1.txt

A shared parameter is defined in a text file that can be linked to a project from the **Manage** Tab:



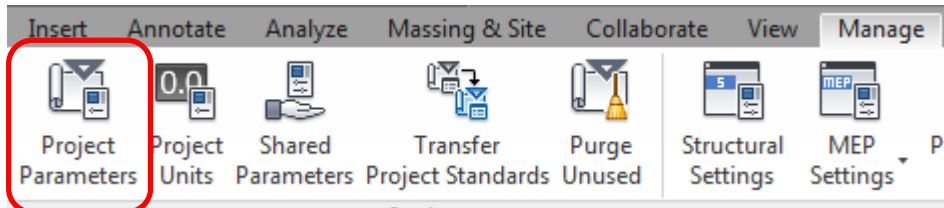
Once the file is opened, it becomes the source for the current project and for all other projects from the current installation.

There are two methods for using shared parameters in a project. The first method includes associating a parameter directly with a **family**. This includes connection parameters, such as **electrical voltage, phase, number of poles** and more:

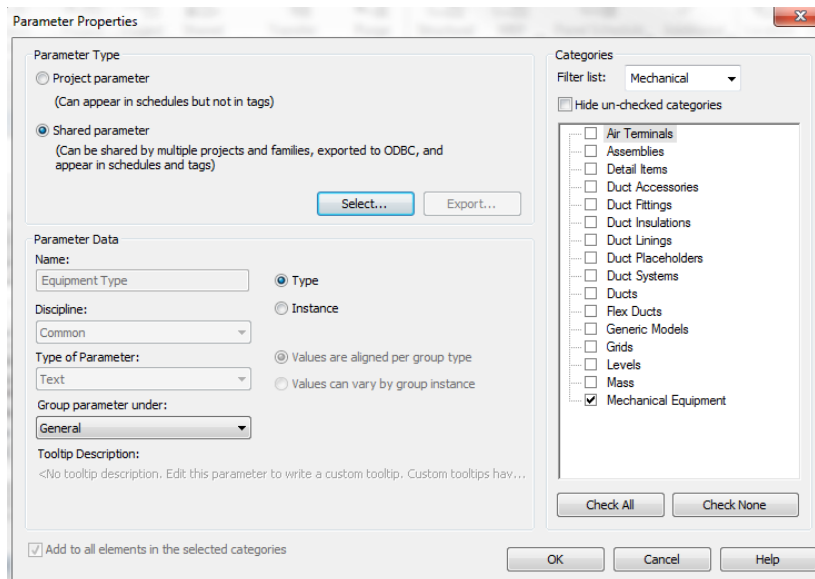


The benefit in associating data using this method is that the parameter is **unique** to this family and type – so, if you only want **specific** parameters that are related to fields in a schedule, it's best to add them to the family. This would include schedule specific items, such as with the ceiling mounted air handling unit shown. Air flow rates, temperature settings and more that are unique to the schedule should be assigned to this family.

Project parameters are another method of adding shared parameters for schedule, but the application is more general. Project parameters are assigned to overall **categories**, even when defined using a shared parameter field. For example, if you wanted all mechanical equipment in a project to use the same shared parameter, such as an **equipment type** field, then you would add it here:



When the dialog opens, use the **Add** option to create the **Equipment Type** project parameter:



Since the settings for this data are defined by the parameter, the **name**, **discipline** and **type** are locked. You can choose to assign the data to **types** or **instances** of the selected **category**. In this case, you can use the equipment type parameter to help you filter schedules for mechanical equipment, which includes air handlers, pumps, coils and more.

Once this is added, then every **mechanical equipment** component in a project will automatically include the field. The user simply should edit the **type**, to change all examples of the equipment.

Here's an important note: it's not the **name** of the shared parameter that matters, but the source file does matter. All parameters include a unique identifier known as a **GUID**. This number is randomly assigned when the parameter is defined in the file, and it looks like this:

Revit_Master_Shared_Parameters_v2.1.txt - Notepad

File	Edit	Format	View	Help						
META	2	1								
*GROUP	ID	NAME								
GROUP	1	Dimensions								
GROUP	5	Electrical								
GROUP	6	Mechanical								
GROUP	8	Identity Data								
GROUP	10	Electrical - Loads								
GROUP	11	Mechanical - Air Flow								
GROUP	12	Energy Analysis								
GROUP	14	Mechanical - Loads								
GROUP	15	Structural								
GROUP	16	Plumbing								
GROUP	17	Green Building Properties								
GROUP	18	Materials and Finishes								
GROUP	19	Other								
GROUP	20	Construction								
*PARAM	GUID	NAME	DATATYPE	DATACATEGORY	GROUP	VISIBLE	Connection	Diameter	PIPE_SIZE	
PARAM	aad7c100-3c08-4b0e-a224-3db04707986a	Refrigerant Suction Gas	INTEGER	6	1					1
PARAM	3322e901-ca02-42fe-a7f2-db576614a4d7	Compressor Quantity	INTEGER	6	1					
PARAM	ced7b602-d099-4061-8fc5-10774f7d8808	Exhaust Fan	YESNO	1						
PARAM	09cad502-74ab-4945-9a53-5522ab109284	Actual Refrigerant 2 Flow	PIPING_FLOW	6	1					
PARAM	e56f2f04-58ff-4786-9d0e-977ceea6ac5	Minimum Circuit Current	ELECTRICAL_CURRENT	10	1					
PARAM	6d3c6004-dce9-4ccf-9320-148946c8b5bc	Heating Seasonal Performance Factor	NUMBER	12	1					
PARAM	137c0e04-d89d-469f-9fa9-b926e1d1104a	Actual Exhaust Air Flow HVAC_AIR_FLOW	11	1						
PARAM	987ca005-e391-496b-8440-33ba8ef9dff8	Economizer	YESNO	6	1					
PARAM	24452f06-fde6-42b5-8cd5-8d44e579f382	Coefficient of Performance	NUMBER	12	1					
PARAM	cdafdf06-7a58-4c1f-820f-264a9d5af216	Serial Number	TEXT	8	1					
PARAM	d449e006-9ce0-425b-9f6c-a75630dafad0	Equivalent Direct Radiation	AREA	6	1					
PARAM	3dbe6f06-8ca1-4c48-a078-38d84262de86	Heating Entering Dry Bulb Temperature	HVAC_TEMPERATURE	11	1					
PARAM	32294a07-cce7-49df-b0f8-ca6a05ae52e3	Flue Diameter	HVAC_DUCT_SIZE	1	1					
PARAM	2bee6a07-d014-4303-ba02-a73157ba6cf8	Flushing Technology	TEXT	16	1					
PARAM	0b538507-88db-4d93-9a9c-6903adcc42a6	Power Factor	NUMBER	5	1					
PARAM	a388f307-7830-415e-b00f-4cf681c73432	Actual Fan Powered Box Primary Air Flow HVAC_AIR_FLOW	11	1						
PARAM	ad17b208-6987-4c58-b5d3-2b5bac288248	Return External Static Pressure HVAC_PRESSURE	11	1						
PARAM	a9395c09-4d77-4c60-9cae-74a955d7aa21	Steam Pressure Drop	PIPING_PRESSURE	6	1					
PARAM	7bbe7609-fbeb-4e09-80af-e55f5b8d76ac	Heating Efficiency	NUMBER	6	1					
PARAM	a46d8a09-ebb2-4ac9-9771-fa05c0888dc1	Actual Hot Gas 2 Flow	PIPING_FLOW	6	1					
PARAM	0a77a20a-4a06-490f-80e0-421f05a6a374	Typical comment	TEXT	8	1					

For example, **Compressor Quantity** is a **common, integer** based parameter. What makes it unique is the number, **3322e901-ca02-42fe-a7f2-db576614a4d7**. If you use another shared parameter file, and create the same parameter, with the same case, and the same value, this number would be different. This causes the parameter to appear twice in a project...and chaos begins to reign.

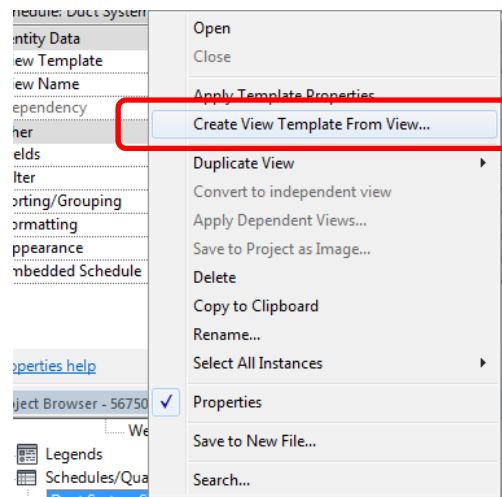
It's important that you sit down with your BIM specialist or manager, and determine what data you want to include with your families and projects, before starting the job, to eliminate duplicate and unnecessary fields.

So why is it important to understand how these parameters work, and how does it affect culture change in a firm? The main reason is the one thing most firms don't like to talk about...STANDARDS. By having all schedules defined using the same basic parameters, adding them to a project template, and having them predefined makes less work for the design team. It creates a common look and feel to the documents, and assures that the minimum data need for the contractor is included, and coordinated, with all objects in a model. Data only should be entered once when done correctly, saving a tremendous amount of coordination time.

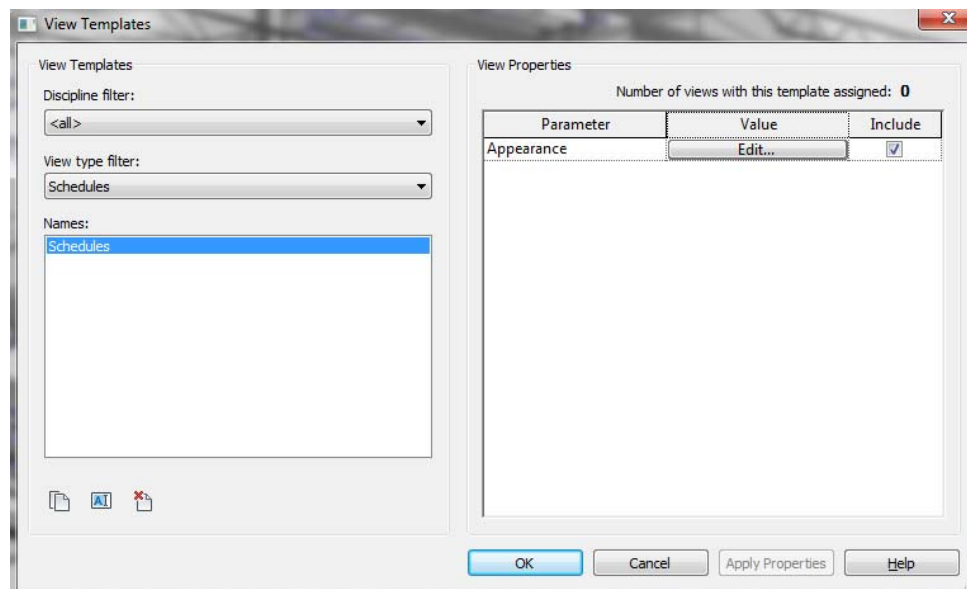
Making Schedules Look *Purty*...(Southern for Nice!)

Let's close this out by taking care of a little drafting business. Since we have multiple offices across the country and overseas, sometimes getting stuff just to look the same can be challenging. Recently Autodesk added a real time saver to projects. In addition to traditional view templates that control object visibility for plans, sections and elevations, you can now include a **view template** for **schedules**.

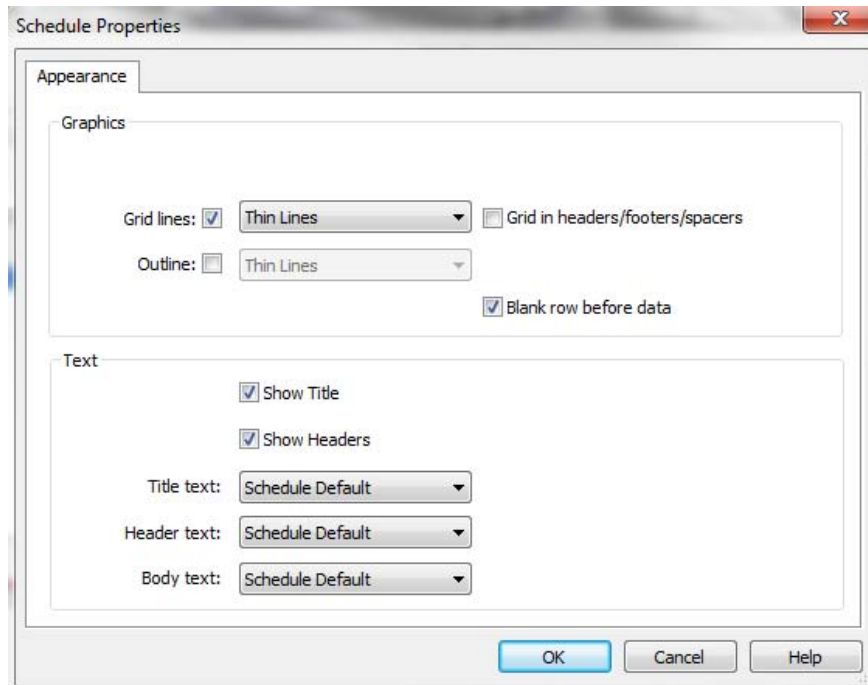
1. Select any schedule in a project. Right click, and then choose **Create View Template from View**:



2. Name the template **Schedules**, and then select **OK**. The **View Template** dialog will appear, and is already filtered for schedule views:



3. Select **Edit** for **Appearance**, and the **Schedule Properties** dialog will appear – but only display the graphic **Appearance** settings:



4. From here you can set the **line style** for **grid lines**, the **outline** of the schedule and whether to include a **blank row before the data**. For the **text**, you can control the **visibility** of the title and column headers, and set the **text style** for the **titles, headers and body** of the schedule. Applying these settings does not change or override the fields, data format or any additional settings for the schedule. It simply makes them look the same on the printed sheet.

Sometimes, it's just these little things, and that's all it takes to make a project manager and client happy.

Conclusions

BIM projects represent the same culture change that occurred when the Beatles arrived in America, when disco finally died, and when working on a computer became a daily "thing". The key is not to let yourself be intimidated by the change, but instead learn to embrace it, and take advantage of the positive changes it can bring. Take the time to understand how to deal with the changes, and you'll be on your way to more efficient design workflows, and profitable projects.

For more tips and tricks, check out my blog at mep-cad.blogspot.com – thanks for attending!

David B.