From Laser Scan to Facilities Management: A Workflow Case Study

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FM2589- The inclusion of point cloud support inside Autodesk® Revit® software means that documenting existing facilities is now easier than ever…hypothetically. With the advent of facilities management software and operations and maintenance databases reaching out to Building Information Modeling (BIM) for visualization and representation, the workflow seems obvious. Follow us through a real example of taking a building with no drawings from laser scan data to intelligent model, then to a computerized maintenance management system (CMMS) database, and finally to facilities management tools.

Learning Objectives

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

- Work with laser scans in Revit to build a model

- Populate a Revit model with data for management downstream

- Push the Revit model export into facilities management software and tie it to a CMMS database

- Describe the limitations of the process and explain what to expect upon delivery from providers

About the Speaker

Aaron is currently the BIM Manager at The Beck Group, specializing in Revit Implementation. His current role includes streamlining use of the program, exploiting its efficiencies amongst the Architectural Design, and Construction groups at Beck, as well as Revit Infrastructure Management and Training for all users. His work experience includes Implementing and Support Revit in a variety of offices, and using Revit for all phases of Architecture (from Design to Construction including fabrication), on projects of varying scopes and genres. Passionate about Revit and Architecture, he's an avid contributor on AUGI (twiceroadsfool) RevitForum.org (twiceroadsfool) and is active in the Revit Community.

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Project introduction (5)

Create a model of an existing facility

The goal of the project was more a focus on using a Building Information Model for Facilities Management, than it was on creating a BIM from the as-built condition. As that was, however, there were (at the beginning of the project) no drawings of the buildigns to be used, and they were built without the use of BIM. So model creation (from Laser Scanned Existing Conditions) became the first step in the project itself.

Input data from devices on site in to the model

Once a Revit Architecture and Revit MEP model were built to represent the existing conditions, staff went on-site to gather the necessary information off the devices in the buildings. Identification numbers, system connections, primary or secondary devices, etc. The data then had to be pushed back in to the Revit Models, to be used in the Facilities Management software.

Put the model in to an FM System, that ties to a CMMS

For this project, we were using Ecodomus (http://www.ecodomus.com/) as the FM tool. The goal was to bring in the Model, using Ecodomus with (or in conjunction with) a Computerized Maintenance Management System. Ecodomus would then tie the Maintenance queries with the objects from the original Model, providing visualization, required information for service, product manuals, and other valuable information.

Work with Laser Scans in Revit to Build a Revit Model (30)

Decide why you are working from a Laser scan
A pragmatic discussion about why you are modeling from a Laser Scan, and what you hope to gain from it, my vastly affect the direction and methodologies you take with the scan itself. In general, we are using a scan for one of three reasons:

Is it only source of documentation?
If there are no drawings, CAD files or Model Files, a Laser Scan makes sense in many cases where it outpaces on site field measurement. But it's very important to discuss the entire modeling process, with the clients. A Laser scan doesn't automatically turn in to a model, so what is the intended level of accuracy against the scan? If a laser scan is your only source of documentation, you'll want to include additional time in your modeling budget, as you wont be moving as fast as normal. Nor will you be able to model as much.

Is it to verify data in documentation?
In some cases you have both: drawings, and a laser scan. In these cases you can plan on moving at a normal pace (working off drawings) and then loading the Point Clouds in for quick verifications. Discussions should be had about what tolerance of deviations between the Point Cloud and the documentation is acceptable, before a change gets made in the model.

What is the expected accuracy and deviation of building versus documentation?
When we build models, certain things are givens: Walls are straight, corners are 90 degrees, unless intended otherwise. Brick walls are flush. Laser scans pick up things that aren't perfect, however. That corner might be 89.14 degrees, and there might be surface deviations in the walls.

It's extremely important to discuss what the **purpose** of the model is. In some cases, that 0.86 degrees might make all the difference. (Coordination in a land locked and tightly constrained building). For FM visualization and representation were better off with the 90 degrees for a number of reasons. But have that talk before starting. This becomes more critical with MEP service rooms (Pump rooms, Sprinkler rooms, HVAC control rooms, etc). From design to fabrication, everything moved. Which set is more important to have in the model?

Scan Quality / Quantity / Intensity

Who is responsible for providing the Laser Scan?
Being that most of us who are providers in AE (or are owners) don't do our own laser scanning, this can be **_extremely critical._** Quality and intensity of the scan will drastically affect your ability to work efficiently (or at all) on the project, and its not just *low* quality you need to worry about. A scan that is off too *high* a quality can be just as detrimental, if not more. My advice? Be

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responsible for the laser scan, if you are responsible for the modeling. Get educated, talk to your scan provider. Explain to them what you *need* and let them tell you how to get there. It's like building a Revit model: Don't ask for everything, or you won't like what you get.

Work time intensifies with Point Clouds

Depending on what you need to deliver from the point cloud (see Decide why…), prepare for process times to be much longer (potential orders of magnitude vary) than they were without Point Clouds. These time increases range from time to convert and place the point clouds, to simple view generation every time you move the model.

Getting the scan in to Revit

In 2013, Point Clouds can now be brought in through Shared Coordinates, but at the time of this project (done in 2012) that wasn't an option. In that case, bringing in multiple scans in alignment with one another had a couple possible avenues:

> Bringing one in (either CTC or OTO) and then bringing the others in "using previous" as the alignment (assuming the scans are all relative to the same system, which‐ working in one building we hope they are).

> Bringing each scan in to its own RVT file, and then linking the RVT files together and establishing Shared Coordinates to control the scan locations.

Performance implications and Hardware Requirements

At the time of this project, our current workstation was an 8GB of RAM workstation (the same machine I'm presenting on today). It's sufficient for most of our Revit models, but loading Point Clouds makes short work of 8GB of RAM. This project didn't have a lot of intense architectural detail, but some of our newer models (without point clouds) require more than 8GB. All of our new workstations have 32GB.

Revit also currently will *only* view the scan in PCG format. Generally, this isn't what youre getting from a laser scanner. That's alright, since Revit converts it on the fly, but modeler beware: For scans as large as we had on this job (unnecessarily large… see lessons learned) the time to convert each one was several hours. It took 3 work days to get them all converted (it does it when you hit Link Point Cloud, and point to the .ptx file).

Modeling from the Laser Scan itself

Building a model around a laser scan goes one of two ways: The scan is present as a background, and you are working around it in the traditional modeling workflow, or: You are using a tool that expedites modeling based on the laser scan itself.

Scan to BIM software

imaginIT- Scan To Bim
Autodesk Feature Extractor (expired)

Using "Scan to BIM" applications will expedite modeling "some" elements. Even though these wares use the Point Cloud to model things like Walls, Slabs, Topo, and Pipes, some of the "expected accuracy and deviation" issues are still present. (How does the app model a flat wall? Does it always model a flat wall? Etc)

Point Cloud visualization aides

Cloudworx
Rhino / Navisworks and API plugins or scripting

These are simply means and methods to change the way the point cloud looks, while working traditionally in Revit. Cloudworx provides section boxing (separately from the Revit view), point density alteration options, coloring options, etc. There are things to be aware of using tools like this, however. Using Cloudworx on a project where not everyone has Cloudworx installed, generates pop up errors for the people who don't have it installed.

Traditional Modeling with the Laser Scan (tracing it)

Traditional Modeling from a Point Cloud doesn't have any magic tricks... It is generally slow going. In some ways, its slower going than modeling from documents, since there are a lot of things you can't see *while* you're in a particular view. In addition, the point cloud shows you *too much* in some views- particularly floor plans- where thousands of points get placed on the floor. There are some fairly simple (and somewhat obvious) tricks to dealing with these things:

Efficient (but simple and obvious) tricks for Point Cloud work

Loading and unloading
This may go without saying, but Point Clouds are heavy. If you can, its preferable to get them in multiple scans, so you can load and unload them, through either Manage Links > Point Clouds, or Manage Links > revit Links.

View Range / Section Box

In general, I try to look at a minimal cross section when I'm working with Point Clouds in Revit, and I *always* make sure the view range or section box ends a few inches **above** the floor I'm working on… Particularly on the ground level. This keeps the points on the floor from showing up, as well as the points that get placed all over the ground outside. In addition, I try to keep section/elevation views only a few inches "deep."

Make the *View grid* through the project

Since I make the views only a few inches deep, here is a habit I picked up from Kelly Cone: Placing an entire grid of section markers across the entire model, in both directions, on both axis'. That way, when viewing a section to look for wall heights, steel heights, etc, you don't have "noise" from all of the things behind it.

Populate a Revit model with data for management downstream (30)

Very critical to success in an FM/Operations venture, is to sit with the team and/or operators *before* building the model, to discuss not only *what* data needs to be present, but *how* that data needs to be present, as it affects the way the model will need to be built.

What modeling techniques need to change for this use case?

Modeling for FM doesn't necessarily mean that you need to model *more*, or that you need to remodel things you've already done, but it might mean *altering* some things about the model.

What content is Shared and Nested for FM uses versus Documentation uses

Content Demonstration- For AE documentation, Roof Top units (example from Autodesk Seek-CaptiveAire Down Discharge Cooling Coil) may be built out of Nested Components, but the Nested Components may be set to UnShared, nested (Don't show up in project, not taggable, do not schedule). This makes sense, for keeping clutter down in the project environment. For management purposes, however, where we might want to track maintenance and service of the individual parts of the RTU, it makes more sense to set them all to Shared. They all get Identity Data then, can be scheduled, and tracked.

Connections to Systems, pipes, ducts, plumbing, etc

If the model is being built specifically for downstream use (and isn't in use for design and analysis… And sometimes, even if it is), the expectation of Systems Connectivity might not be

there. This gets more complex as you consider the (now) Shared and Nested families from above. A plan of attack for which families have Connectors, which are connected to *systems* and which are present simply for tracking data and maintenance issues, is imperative.

What data needs to be in the objects, and in what format

What information needs to be in each object (or each object type) and where that information needs to be populated, is not a small task to consider. The earlier in the "chain" the data exists, the more accessible it is (meaning if it's in the model) but it isn't a requirement. Many of the Facilities tools out there allow the data to be input directly in their tool, or in a Database or Spreadsheet that is output from the model, in an environment that is faster to edit than the Model Authoring tool. So, that means having the client, the Operations team, and the Design team all at an understanding.

What fields of information are needed downstream

Hardcoded fields versus Shared Parameter fields (making your own)

There are a number of Data Structures and Standards that exist already, and one might be mandated to you by the Project team, or the Client. It's important to know the capabilities of each. For instance, OMNIClass parameters and Assembly Code Parameters are automatically included in Revit Objects. OMNIclass parameters only exist, however, in Component File objects. Objects made from System Families (Roofs, Walls, Floors, Ceilings) cannot get OMNIclass information. For FM purposes, if OMNIclass is being used (to track Roofs, and Roof warranties, and repairs, for instance, you'll want to create your **own Shared Parameters** instead of using the Hardcoded ones.

Downsides: This eliminates the functionality of having a selectable table, and relegates you to typing. You can't even effectively use a Key Schedule, unless you make one for every category.

Upsides: It works for all objects.

COBie parameters, since they are released as Shared parameter files, are fairly easy to comply with, as you can add both the Instance and Type Parameters as Project Parameters to all categories.

Type Based, versus Instance based, and Naming/Type Marking

Elements in the model will need to be classified by Type and By Instance, and in most cases their classifications will not be those that are used by your Revit Standards. Family Names in

Revit wont reflect Asset Type ID's used by Facilities, and Mark values (if the model was built for AE Documentation) will not reflect ID's of units. There are options here:

Edit the values manually in the model- You can do this if the client has provided you with Identification values of their own convention, etc.

Export to another system (Excel, DB, etc)- This method can be much faster, if you have an API app that will let you export/import(altered) data from Revit schedules. The reason being you can use Vlookups or formulas in Excel or a database, to make the Shared Parameters you include for the Client Naming System, to read from the data already in Revit.

Be prepared to eliminate:

Stacked Walls- (Nested Basic Walls can't get Identity Data, nor can Stacked Walls)
Model Groups- (Instances cannot have varying Instance data currently, which means Asset Instance ID's (client names) cannot happen without ungrouping
Multiple Instances of Links- If you've used them, they will have to be bound/combined at some point, or they will read as the same elements

Removing items that are present "for modeling only"

Parent Families of Nested Components, or Nested Components for "Revit Convenience." Have a system in place to remove these from the "data exports" that you kick out to the FM ware. If you are working with COBie and the templates provided by Autodesk, they have a system in place for this, using a yes/No parameter: "COBieTypeSchedule."

For internal Cost estimating purposes, this parameter can help eliminate confusion amongst the Construction Team, to eliminate redundant counting (Grab Bar sample, Locker Sample, Seating Sample, etc).

Order of Operations in building the model

While not a major consideration most of the time, the order in which tasks are done *can* affect the outcome, depending on the tools in use, and how they access data from the BIM.

Rooms/Spaces/Systems/Equipment

In this particular project, we learned that Ecodomus accesses the "Space" property of each piece of equipment in the Revit model through the Revit MEP System Browser (while checking

system connectivity), and not through the items properties themselves. This was only an issue because we discovered that the System Browser "Space column" is not the same piece fo data as the "Space column" that is populated in an item schedule, nor does it update accordingly if the object and its space association changes. This isn't a massive issue, but it drives the point home of: Talk with the team, and know what they will be expecting, so you are sure to be able to deliver.

Push the Revit Model export in to facilities management software and tie it to a CMMS database (15)

Warning: Most people are excited about this part, thinking here is where the *easy* button is for making FM happen from an already-created-Revit-Model. There isn't an easy button, and its not as simple as repurposing a model. But, here is what to look at.

What is the software, and what formats does it use?

This part varies from project to project, based on what the tools are that are in your arsenal. Some wares use DWF exports from the Revit verticals, and others (Ecodomus, used in this job) use the Navisworks Exporter. Still others require separate database exports, or schedule exports, and possibly other geometry exports. IFC, SIMe, etc.

(This project) Ecodomus- Navisworks export, and ODBC export

How does the software interpret exports?

DWF- Parameter data missing if null value.
A disappointment in how DWF's are made, is that parameter data that us null just evaporates in making the DWF. The Parameter Name will not show up (blank) under the objects properties, it will simply be gone. It hasn't been a huge issue for us, but if youre trying to manipulate visualization of objects based on data later, keep it in mind.

Shared Nested Families- Ability to select them (can you see them, should you)
As with exporting a model to any ware, you should have specific settings that are preconfigured, that stay that way. This becomes more relevant if your model (for design and documentation) has things in the model that they won't want to see in Facilities and Operations work: As an example, we have modeled Door Swings and Space Clearances. You want them subcategorized and defeatable. You also need to communicate to the **FM operators** how Nested/Shared families work, lest they get confused when they cant select the pieces they need.

Element ID versus Naming strategy, how do you configure your model?

Another important conversation to have (recurring theme…) is which data fields is the FM side using for their part, versus the "Revit" and "Documentation" side. Where possible, I would steer away from the "Revit Sacred" fields (fields you cant always do whatever you want with) such as Family Name, Type Name, Mark and/or Type Mark (when they are used in Documentation as well). While it is more work, I prefer to use parameters specifically meant for FM. This way, if you come across a Clients Naming standard or convention that relies on more than one object being named the same thing (even though they aren't), you don't have to hack a way around it.)

If your plans is to embed as much of the data in to the model itself, and not just handle it post-export, look in to an API solution to help with this. Autodesk has a free app that helps with (some) COBIE data automation, but not much. Several addins on the market, however, will allow for the Export of a schedule to Excel, and then a re-import with modified data. These are gold mines for FM data entry. It means not needing someone Revit Savvy for the data entry, and also not dealing with Revit schedule Limitations, where Excel can enter faster through formulas and auto-completions.

Describe the limitations of the process, and explain what to expect upon delivery from providers (15)

Point Cloud Modeling

Time to convert in to PCG for Revit (days)
This was due to the unnecessarily excessive size of the Point Clouds, on this particular project. The time to convert 10,000 SF of Point clouds from PTX to PCG was 3 full work days.

Data input in to Revit

Expectations- Talk ahead of time
As this model wasn't built for design and documentation, originally our discussion was that generic "boxes" for pieces of equipment could be used, as what was important was the "information" in the families, not the shapes of the families themselves. Expectations change, however. Have a sample of a Generic Placeholder available, or be ready to start making very specific content.

This is extremely important for MEP equipment, as there are many makes and models of the fittings, valves, electrical boxes, pumps, and so on.

Order of operations unexpected meant large amounts of rework. Some of this is out of users hands

Connection to CMMS through Ecodomus

Room / Space / Zone associativity caused issues (and mitigating expectations)

Order of Operations limited the functionality of the System Browser, which the Modeling Team didn't realize was an issue. Only recourse was to cut and paste items back in for Space associativity, and then to reconnect all of the systems.

Plenum returns = no Space association = errors in the model. There was an expectation of a "zero warning model," because someone in the Facilities team had been advised that it was a realistic goal. Have a BIM execution plan, and discuss these items ahead of time. As it stands today, the Architectural model alone has 20 warnings (the not resolvable kind), and the MEP model has a number, due to "poorly designed Systems." Since we were modeling as –built's and not re-designing the systems, those are not resolvable.

Handy Links:

Data Formats:

http://www.omniclass.org/ (Tables in PDF and Excel for reference)
http://usa.autodesk.com/adsk/servlet/oc/offer/form?siteID=123112&id=18070390

(COBie toolkit for Revit- I recommend using this to get the parameters and schedules in *your own* template, and then using the Addin itself. I would not try to work in their templates… They are bare).

Facilities Software:

http://www.ecodomus.com/ (Facilities Management Tools used on this project)
http://www.fmsystems.com/products/bim_revit.html FM Systems Interact

Point Cloud Management:

http://imaginit.com/software-solutions/building-architecture/scan-to-bim ImaginIT Scan to BIM
http://www.leica-geosystems.us/en/Leica-CloudWorx-for-Revit_97854.htm Cloudworx for Revit