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BLD124663

ReCaping a 7 Trillion Points Project

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Learning Objectives

- Understanding the need for reality capture within today's modern design firm. Learn how other design firms are dealing with as-built condition and how they plan and implement this technology within their firm.
- Understand how to move from raw point cloud data to a Revit Model and different strategies for managing large data sets with ReCap
- Learn different strategies for managing large data sets with ReCap plus leverage how Collaboration for Revit on large as-built model with teams in remote locations
- Review the lessons learned throughout the collaborative process between SolidCAD and DIALOG from a project management point-of-view, and discuss the benefits and challenges the team encountered in realizing an intelligent architectural 3D model.

Description

Last year our team undertook the task of capturing and generating the existing condition of a building in downtown Toronto. This project was a commercial building that included a parkade, mechanical spaces, office areas and retail space. It required over 1100 scans, or 7 Trillion points of data to capture all spaces needed for redesign and as-built modeling. This Revit project required LOD 200 modeling process for Architecture, Structure, Mechanical, Electrical and Fire Protection. Leveraging Revit, Recap and Collaboration for Revit we were able to effectively move from raw scan data to a Revit model efficiently. Other challenges were management of large data sets and collaboration with team members in different geographical locations. We will show you how we plan and execute this project and let you know what our lessons learned are.

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Speakers

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Location Edmonton, Alberta
Previous Company SolidCAD a Cansel Company
Current Company Clark Builders
Job Title Virtual Construction Specialist Lead – Southern Alberta
Industry AEC

Reed has been working in the AEC industry for 20 years and with BIM exclusively for the last 13 years. He has work in almost all aspects for the AEC industry from land developers to sub trades. He also specializes in BIM Implementation, Laser Scanning, and construction modeling. Whether it is with as-builts via 3d point clouds or field layout of BIM models Reed has developed workflows to streamline these processes. He also has extensive experience with consultants and has worked as a BIM manager and Support Specialist where he managed models, developed libraries & standards, and supported the technical staff. Reed has worked all types of commercial and Industrial project as large as 1.4 Billion.

Renee Leung OAA, MRAIC, LEED© AP
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Company DIALOG
Job Title Architect
Industry AEC

Renée is a registered architect in Canada with over ten years of design experience in architecture, specializing in commercial and institutional designs. She has honed her design and technical skills while employed at many award winning architectural firms in the past. Throughout her career, Renée has been and remains highly interested in the creative process of design, and in delivering high quality building with Building Information Modeling. She harnesses the power of BIM to produce high quality work and distinguished architecture that can meaningfully improve the wellbeing of our communities and environment.

Krigh Bachmann
https://www.linkedin.com/in/krigh
Location Toronto, Ontario
Company DIALOG
Job Title Manager of Design Technology
Industry AEC

Krigh Bachmann is the Manager of Design Technology for the international design and engineering practice DIALOG. He joined them in 2016 after returning from 8 years in the UK, where he was the BIM Manager for Gensler and Pollard Thomas Edwards. While in the UK, he worked on projects ranging from data centres in Europe and malls in Kuwait, to 1.2 million sq ft office fit outs in the heart of London. He has presented at BILT NA, the London Revit user Group and was an active member of the national BIM for Local Government task group in the UK. Within Canada, Krigh is now engaging with BuildingSmart Canada and CanBIM to assist in promotion and development of BIM in Canada.

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The Role of 3D Laser Scanning in the Modern AEC Firm

Building Information Modelling has become an enabler for the AEC industry. Moving from drafting that was solely aimed at producing drawings to an information rich model environment has unlocked our projects as we continue to explore what we can leverage the new BIM tools and processes. 3D laser scans and the point clouds that they produce, are one example of how we can improve the projects we design, construct and maintain.

Although using laser scanners is still fairly expensive, as with many technologies, the price continues to decrease. This means the technology will become more common place and even within reach of smaller practices and projects. Until then it's still up to the project team to weigh out the cost of the survey verse the benefits of using it.

Benefits of using a laser scan over a traditional survey:

- The shear amount of information: laser scanners can collect millions of points of data in very short periods of time.
- Level of accuracy: the lasers can measure spaces the spaces more accurately than a human with a tape measure or manual entry of measurements.
- Ability to review scans on computers: like a Google Streetview for your existing site, the scans can be opened on a computer and walked through virtually. This gives you a chance to look around without having to spend time going back to site, but also you can measure the site remotely as well.
- Ability to compare the scan to a model: when imported into Revit or similar design software the scans can be compared with against models or traced over and reviewed in full 3D.

There are some drawbacks to 3D laser scanning that should also be considered:

- It's expensive compared to traditional methods.
- The size of files are huge to store and transfer.
- The processing power required to open and manipulate the files is a lot.

If you are considering using a laser scan on a project, remember that it's not ideal of all situations. It's most useful when you are dealing with an existing site or building that has conditions that are not easy to measure or has a lot of areas that need to be measured. But keep in mind that you need to have access to everywhere you want to scan. This can be problematic for public facing areas, areas of sensitivity, or areas with a lot of obstructions. You also don't want to scan areas before demolition. It's better to wait until the area is back to the conditions you will construct in, so everything is exposed (laser scanners cannot see through walls and ceilings that are going to be stripped out). Laser scans can also be very useful to record as built conditions to ensure models are reflective of actual conditions.

There are different possible when you consider who could do the scan. It could be done internally or externally. A lot of that is decided by the business case behind it. Look at all the costs and

factors weigh them out. When you factor in the cost of the unit, time/cost for training, time to do the scan and if you are building a model, you have to take all of that and look at how often you plan on doing it and if you have enough projects to warrant the investment. Outsourcing this to a technology group or surveyor sometimes makes more sense if they will be using the equipment and training enough to recoup the cost.

This of course is changing as the cost of the technology is dropping. With the announcement last year of the Leica BLK360 and similar units coming on the market at much lower prices and easier to use interfaces, it might become more economical for AEC firms to have scanners in-house for use by their own staff. Consider that a full laser scanner normally costs somewhere around $65,000 USD, but the BLK360 only cost $15,000 USD.

THE LEICA BLK360 ($15,000) WORKS WITH AN IPAD AND RECAP PRO

You can also look at hiring someone to do the scan only. Although they can scan and model it for you, it might be more cost effective to choose someone else to model from the scan. You can do it in house, hire someone external including sending it overseas to firms that specialize in just converting scans to models.

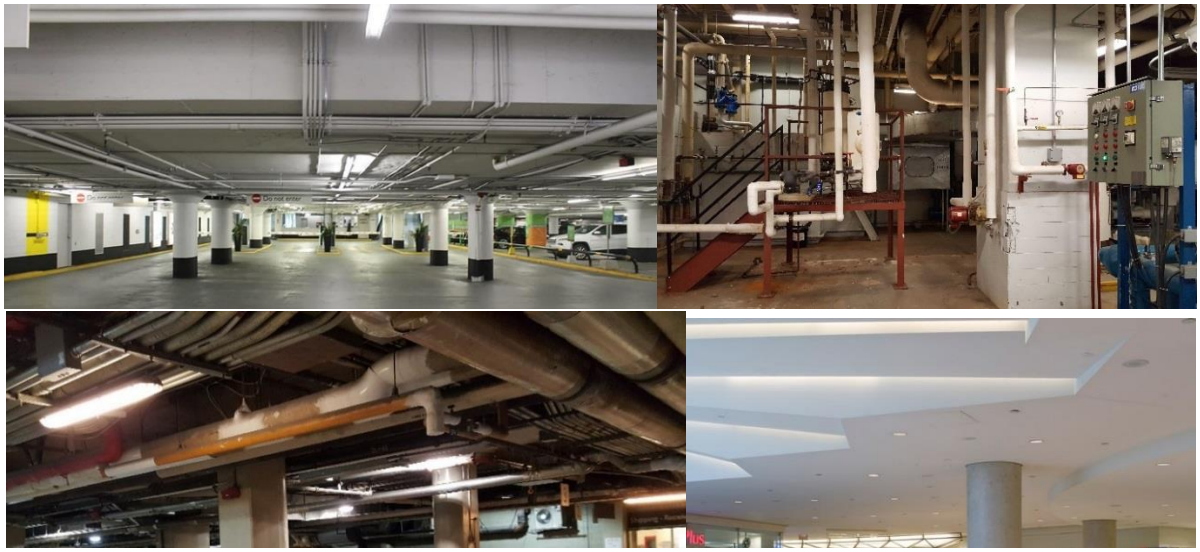
So how do you find someone to work with to scan and possibly build your model? Like anything, you want to shop around to get comparison. Not all surveyors or technology groups are the same. Get more than one quote and provide them with as much information as possible. Even create a specification for the job. If you are looking for example, look at the Plowman Craven BIM Survey Specification. This is a group from the UK that provided this as an example of how you should specify your scan and how detailed you need the model to be.

If this is the first time you will be hiring someone to do a scan for you, consider the first project as a pilot project. If you find a good partner work with them to learn as much about the process. If possible, see if you can "watch over their shoulder" for parts of it so you know what is involved and can apply that to future projects. If you find a good partner, they will want to build an on-going relationship with you so that you will offer them a chance to bid on the next project.

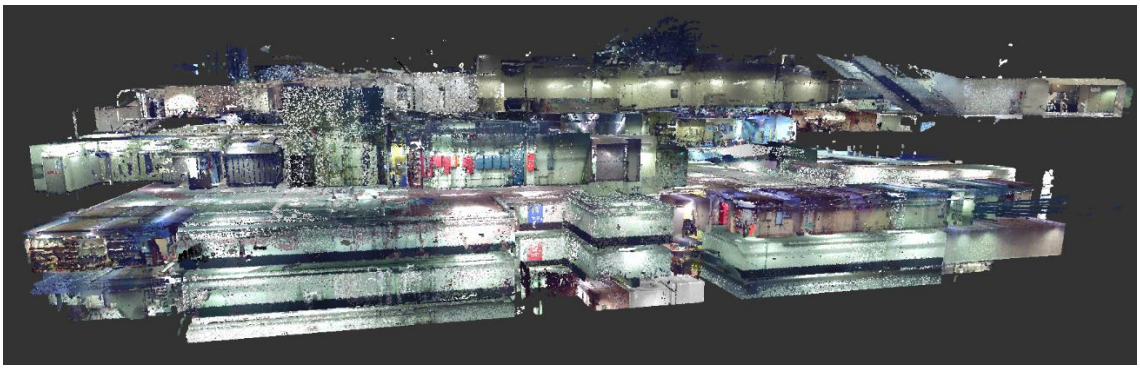
Project Overview - A Quick Summary of Our Scope of Work

The case study project is located at the heart of the financial district in the downtown core of Toronto, Ontario. This commercial complex occupies one full block in the city with a minimum lot frontage of approximately 460 ft long and a lot area of approximately 180,000 sf. The entire complex comprises of commercial office buildings at and above grade, commercial retail level below grade, and several stacked levels of parking and major service spaces in the sub-basement.

The goal of the project is to capture all architectural, structural, MEP, and fire protection information of the existing conditions of all the below grade levels with accuracy, and produce intelligent 3D as-built models for the future design development of this adaptive reuse project. Owing to the complexities and the extensive scope of work, the schedule of the project, as well as the phase of the redevelopment, it was a logical decision for DIALOG to engage an external reality capture consultant, in this case SolidCAD, on this surveying mission.

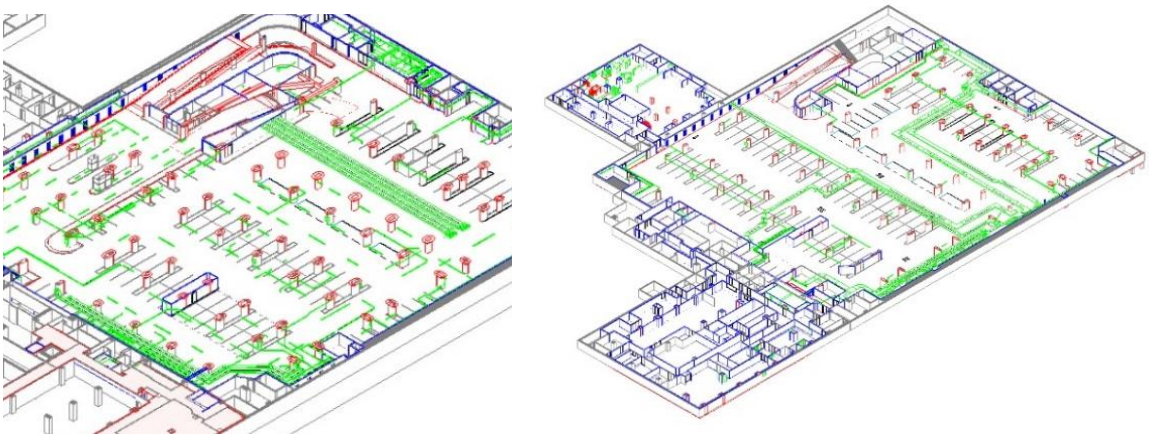


EXISTING CONDITIONS: LARGE AMOUNT OF STRUCTURAL, MECHANICAL AND ELECTRICAL COMPONENTS, AND COMPLEXITY OF INTERIOR GEOMETRY.



PORTION OF POINT CLOUD SCANS.

PART OF REVIT AS-BUILT MODEL.



PART OF REVIT AS-BUILT MODEL.

Project Data Statistics:

DESCRIPTION	QUANTITY / TYPE
LEVELS	5
NUMBER OF SCANS	1150
TOTAL SIZE OF SCANS	200 GB
NUMBER OF SCAN REGIONS	21
TOTAL TIME TO SCAN	40 Hours
TOTAL TIME FOR REGISTRATION	32 Hours
COLLECTED SURVEY DATA	Yes
RESOLUTION SETTING	Res ¼ , 1/5 (5-7 mm at 10 m)
QUALITY SETTING	3x and 4x based on condition
TARGETS USED	Sphere and Checker Board
NUMBER OF TARGETS	3-4 common target within adjacent scans, 3x5 target (15 targets) at each scanning session
EQUIPMENT USED	Robotic Total Station Faro x330 High-End Desktop PC for registration, processing and Cleanup Mid-Level Laptop PC for cleanup, extraction and modeling

Understand how to move from raw point cloud data to a Revit Model and different strategies for managing large data sets with ReCap

Unfortunately, there is no way to easily convert point clouds to a Revit model. However, by planning and leveraging the right tools, we can significantly speed up the process while providing higher level accuracy.

PLANNING – Planning, experience, and understanding:

Like everything in BIM we need to plan to help reduce rework, scan efficiently, and to facilitate success. A few things to consider before scanning:

- What is the goal of this scan?
- Location of the scan.
- Are there unique challenges to this site?
- What is the client's expectations?
- How many scans do we require?
- Is there and existing design model?
- What Level of Development do we need to model?

LEVEL OF DEVELOPMENT (LOD) – Understanding LOD is critical

What is Level of Development?
LOD, in building information modeling (BIM), refers to the amount of detail, information and accuracy of the BIM.

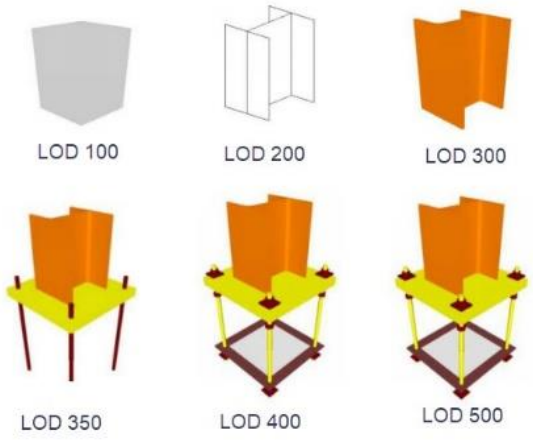
LOD has been defined many different ways but one of the widely accepted standards is from the Architect Institute of America (AIA). Here are the rough definitions:

LOD	DESCRIPTION
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
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
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, location, orientation, and interfaces with other building systems. Non-graphic information may also be attached to the Model Element.
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.
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.

The Specification can be found at: http://bimforum.org/lod/

Level of development is important detail to know for a number of reasons:

- Time and effort have direct correlation to LOD. The higher the LOD the more time and effort it takes to model.
- The cost of an LOD 300 can be double the cost of LOD 200



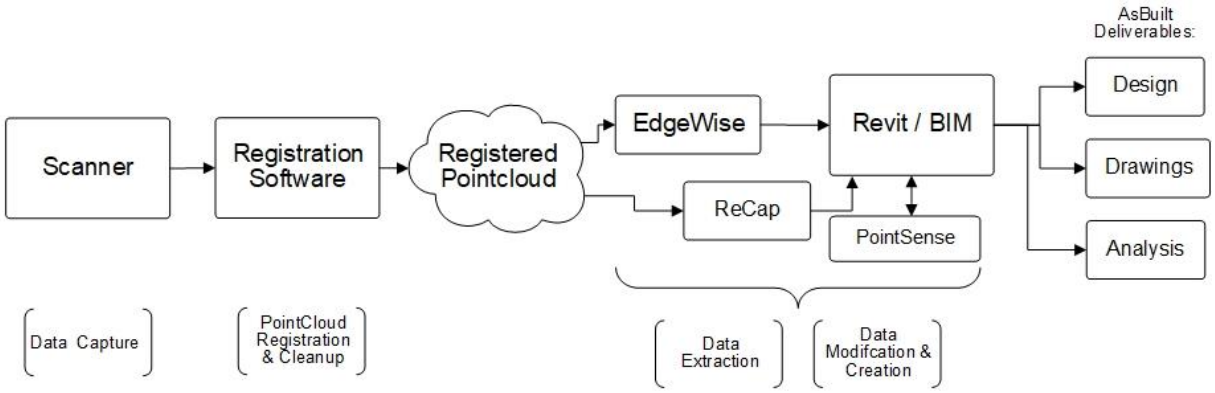
LOD 100 TO 500.

- A good rule of thumb is to model to the requirements of your goals. If you need more detail in some areas and less in other areas, then use a mixed LOD approach. LOD in as-built modeling is about value, getting what you require.
- For this project we discussed with DIALOG and as a team we decided that LOD 200 was appropriate for this project. The Reasoning as follows:
    - Use was for preliminary design work
    - Used to QA/QC the traditional 2D as-built
    - Value vs cost
    - DIALOG has the staff to increase LOD to 300 if required

Workflow and Process "Scan to BIM":

Leveraging tools helps again accuracy and speed:

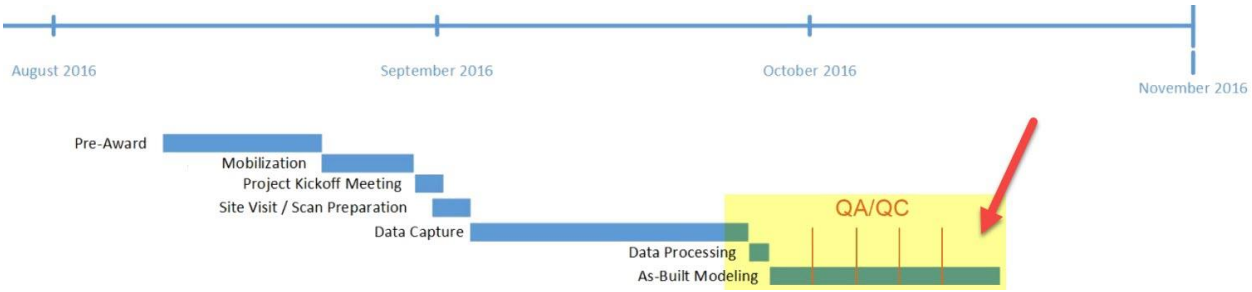
- Getting scans at different elevations is a must
- Modeling directly from a point cloud in Revit is possible but cumbersome
- Leveraging automatic and manual extraction tools are key
- Recap does an excellent job on indexing and can create individual regions
- If there is a design model survey data is needed to align clouds to models.



In depth workflow process explained:
https://www.youtube.com/watch?v=DcjHGc3Z24w

Workflow Process Overview of Key Milestones:

Here is a brief step by step guide of how we moved from Raw point cloud data to and LOD 200 Revit model:



Project Planning

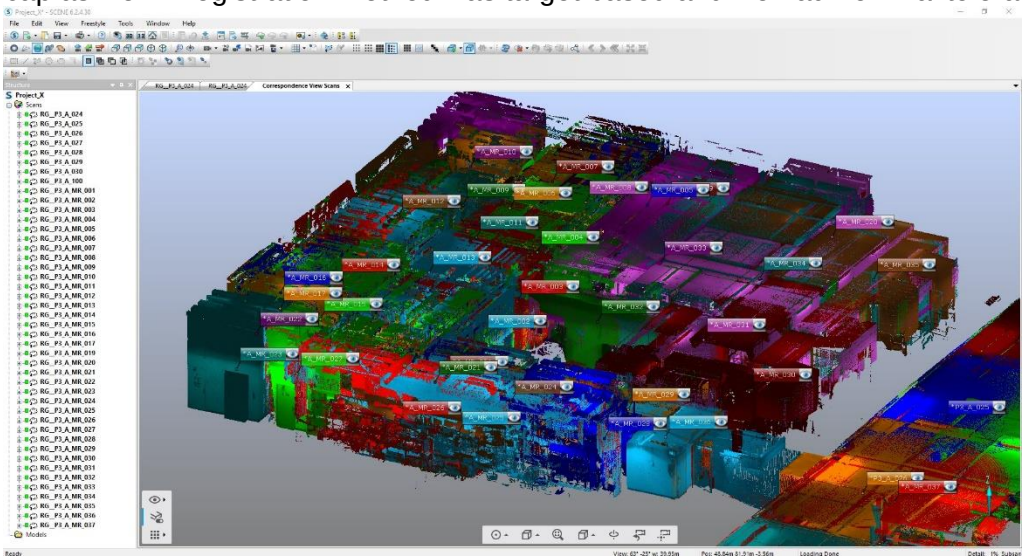
Planning was key and meeting will all important members on site was critical. From this meeting/site visits we determined that scope was larger than anticipated from previous drawing and photos. Also determining site conditions and potential issues helped us navigate them prior to scanning.

Scanning

Scanning took over 40 hours to complete. The data capture of this project utilized 3-4 common targets within adjacent scans and 15 targets at each scanning session. As there was an existing model we also surveyed key areas to help us locate the point cloud with the model and help increases accuracy from floor to floor at the registrations phase. Challenges included: access to high security areas, coordination with tenants, and busy areas.

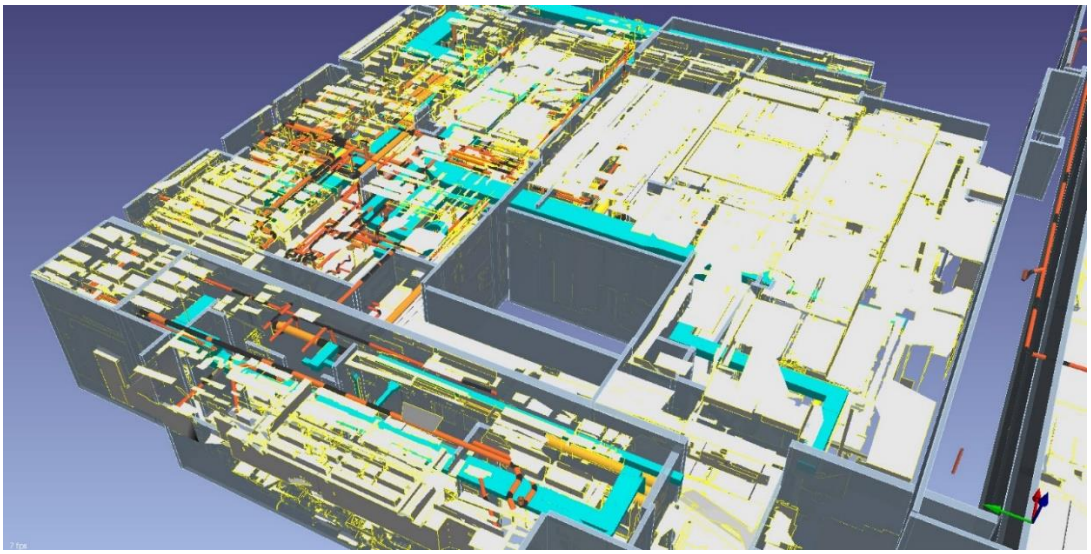
Processing

Processing, Registration and Cleanup took over 25 hours to complete. Faro Scene was used for both activities, then was saved as a registered FLS file set and exported to Recap as well. Registration method was target based and we had nominal tolerances.



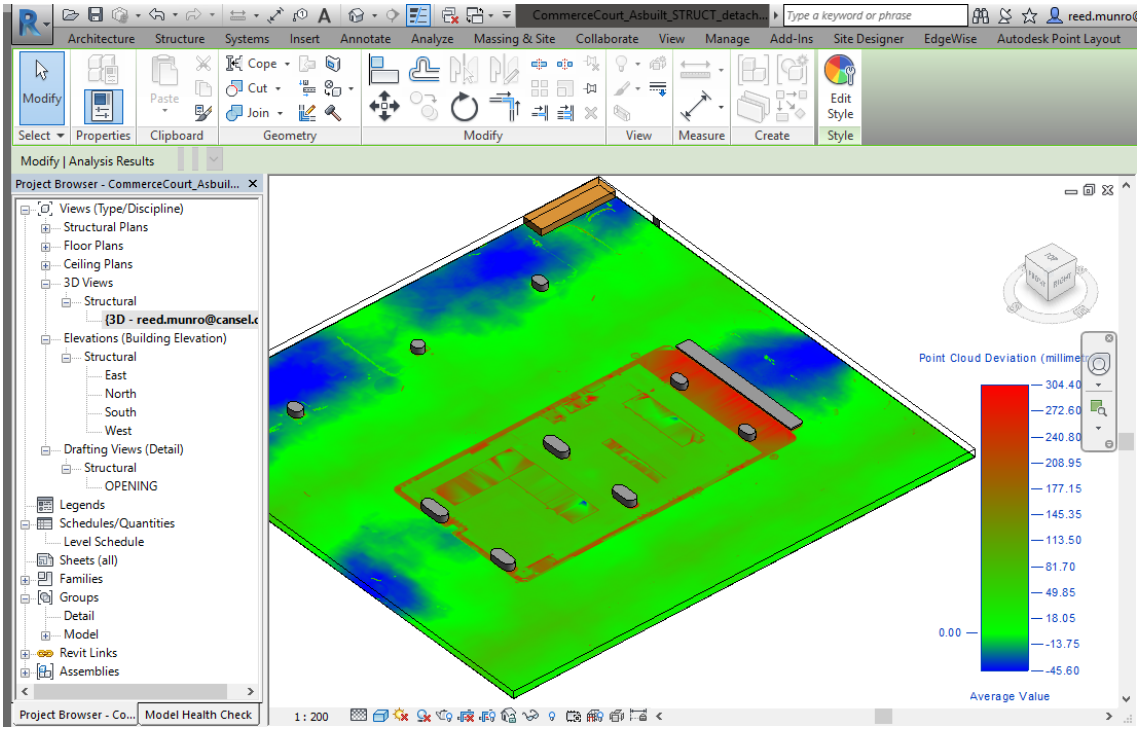
Extraction

Automatic and semi-automatic extraction was completed using Edgewise. Elements extract from the point cloud included: walls, windows, levels, structural steel, pipes, ducts, and planes. All these elements were then placed in Revit as Revit elements.



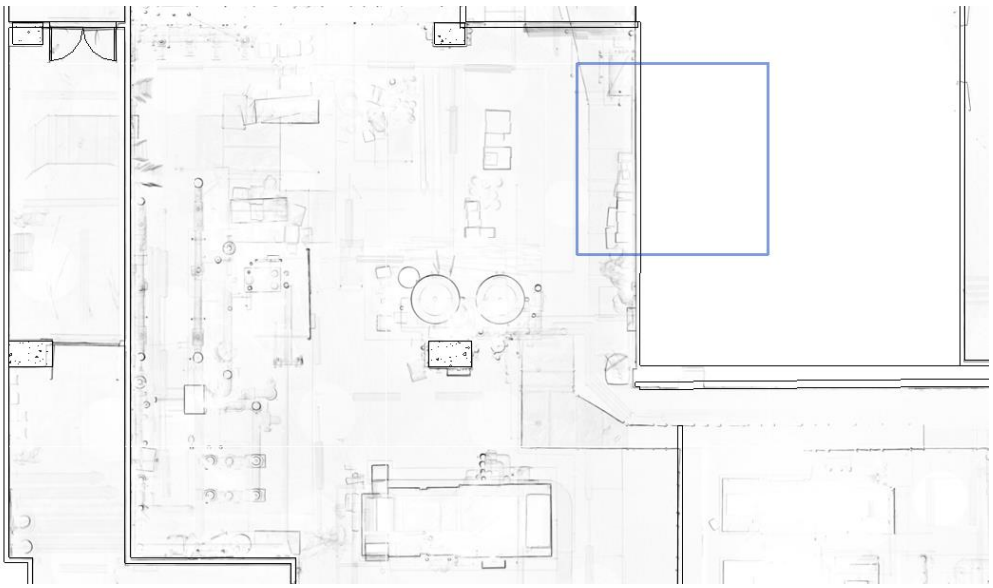
QA/QC

As a double check (Quality Assurance / Quality Control) we checked the extracted data compared to the point cloud. We utilizing Edgewise and Pointsense to do this. These tool would create a heat map of the comparison between the PC and the elements to examine the differences.



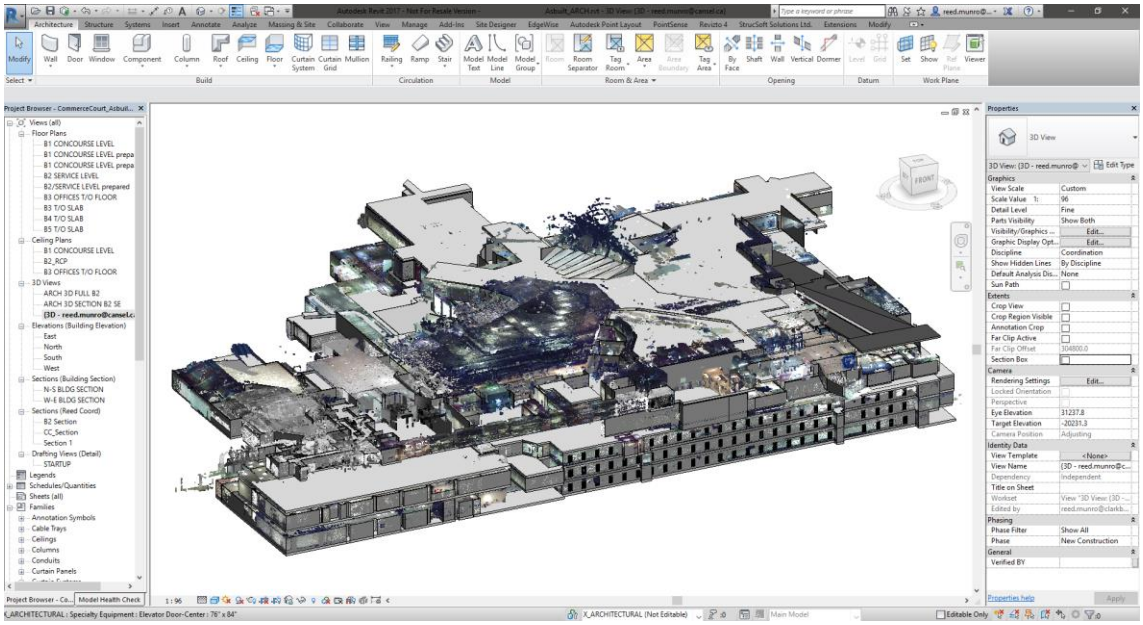
Modeling

With the aid of Faro Pointsense we completed the model within Revit. Orthoimages were used to help with tracing and assure accuracy. With our team of 3 we completed the modeling of the as-built within 6 weeks. As we were in remote locations, our team utilize Collaboration for Revit so we can all work with in the same model. We linked the Structural and MEP models to the Architectural model.



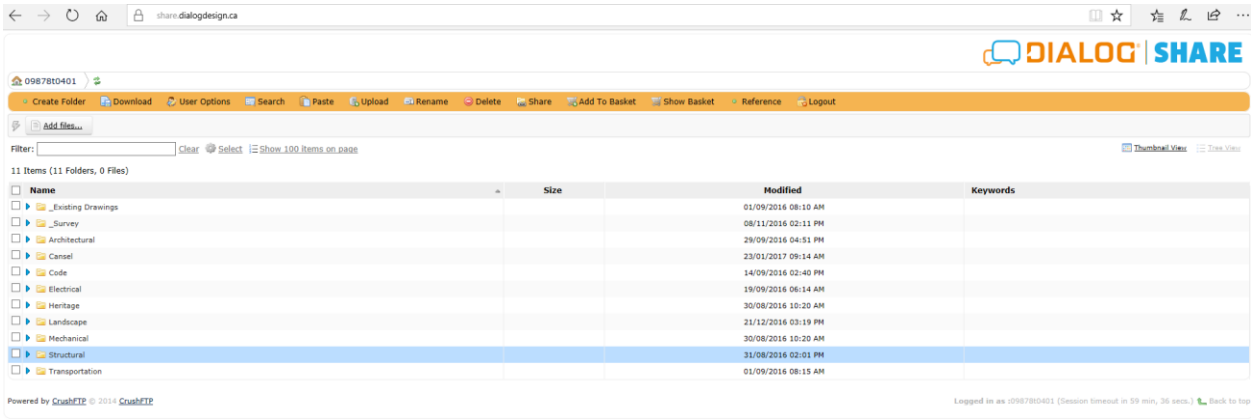
Handover

Final deliverables were upload to DIALOG. This included a Revit models, families, and point clouds.



Deliverables:

Revit model, LOD 200
ReCap Point Cloud complete with color and photospheres

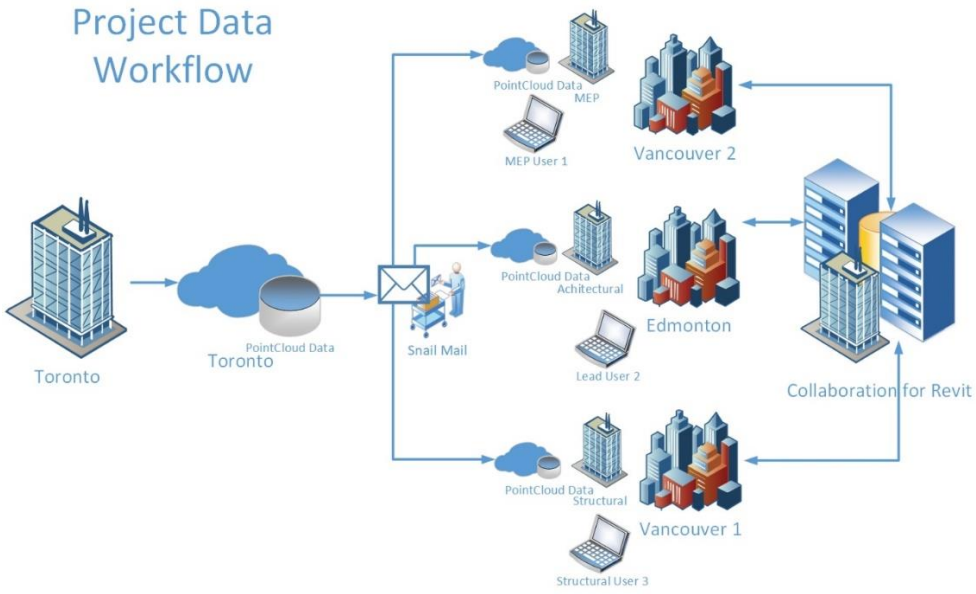


Different strategies for managing large data sets with ReCap plus how Collaboration for Revit on large as-built model with teams in remote locations

Dealing with large data sets is the norm when it comes to point clouds. Add remote teams into the mix and you have potentially a lot of headaches and bottle necks.

Team Break Down

- Client / DIALOG Staff: Toronto
- SolidCAD / Cansel Staff:
    - Scan Team: Toronto
    - Modeling Team: Edmonton and Vancouver



Data Transfer:

- Project was located in Toronto.
- Collaboration for Revit was used and worked really well. However, C4R doesn't support point cloud data so a copy of the point cloud RCP and RCS need to be locally saved for each modeler.
- We initially were going to sync point cloud data via Google Drive but was problematic. Upload times were too slow and data would go "missing"
- Ended up defaulting to sending USB hard drives via snail mail
- FTP was used for final deliverable to DIALOG

Hardware and Cloud Computing

HARDWARE	PROCESSOR	RAM	GRAPHICS CARD	HARD DRIVE
HIGH-END PROCESSING DESKTOP	2x Xeon	32GB	6GB Nvidia	1TB SSD & 2 TB HD
MID-RANGE MODELING LAPTOP	i7 Intel	16 GB	4 GB Nvidia	1TB SSD & 2 TB HD
LOW-END MODELING LAPTOP	i7 Intel	32 GB	2 GB Nvidia	1 TB SSD
VIRTUAL MACHINE	Multi Xeon	64 GB	2 Nvidia 4 GB	1 TB virtual HD

- Point cloud processing utilized a high-end desktop pc specifically built to process, register, and cleanup. This step went smooth.

- Extraction, cleanup and model utilized a mid-end laptop pc and was barley sufficient.

- Hardware solution was to use a scalable virtual machines service. These machines were scalable with multiple CPUs GPUs and up to 64 GB of RAM. Files were access via few different cloud services, in this case Google Drive. The system would host our license as for the software we were using. While being compliant with Autodesk.

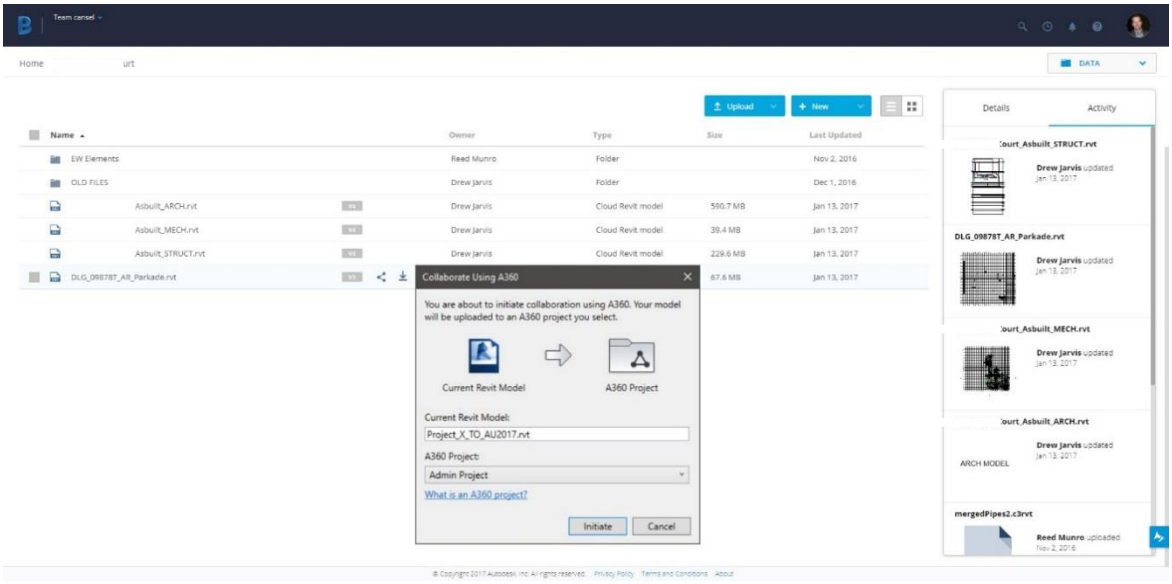
- After a month struggling and trying to make this system work for us we decided to switch back to traditional hardware, upgrading one machine and use different strategies to manage the data so that it would work on our hardware.

- Data management solutions was to leverage Revit's ability to link data and load elements on demand. Large USB 3.1 External hard drive with a common drive letter was utilized to host the link data.

- ReCap's ability to create scan regions was key the success to this project.

Collaboration & Communication

- Collaboration for Revit really was the way to go. It allowed for real-time modeling and help keep everyone one on the same page.
- Our everyday communication tool was Skype which included people outside of the Revit team.
- Standard email was used as well.



Technical Lessons learned

- Cloud VMs only work with large band width. The distance to data center needs to be as close as possible.

- Modelers need to have some experience with point clouds
- Scanning to LOD300 would be extremely time consuming
- Access to site need to be better
- Sometime old methods are the best (i.e. Mail)
- 2D as-building can be very inaccurate
- Revit can be limited for as-builts in due to design constrains
- No one tool can extract all elements
- Eventual you will trace in Revit
- Preliminary site visits are critical
- Set expectations
- Hardware can make or break profit.

Review the lessons learned throughout the collaborative process between reality capture consultant and architectural team from a project management point-of-view, and discuss the benefits and challenges the team encountered in realizing an intelligent architectural 3D model.

DIALOG collaborated extensively with SolidCAD on this 7-trillion-point project. Leveraging SolidCAD's expertise on Scan-to-BIM service, DIALOG is able to utilize the point clouds and Revit models to verify existing as-built conditions with precision, and to further advance the design of this challenging adaptive reuse project with accuracy.

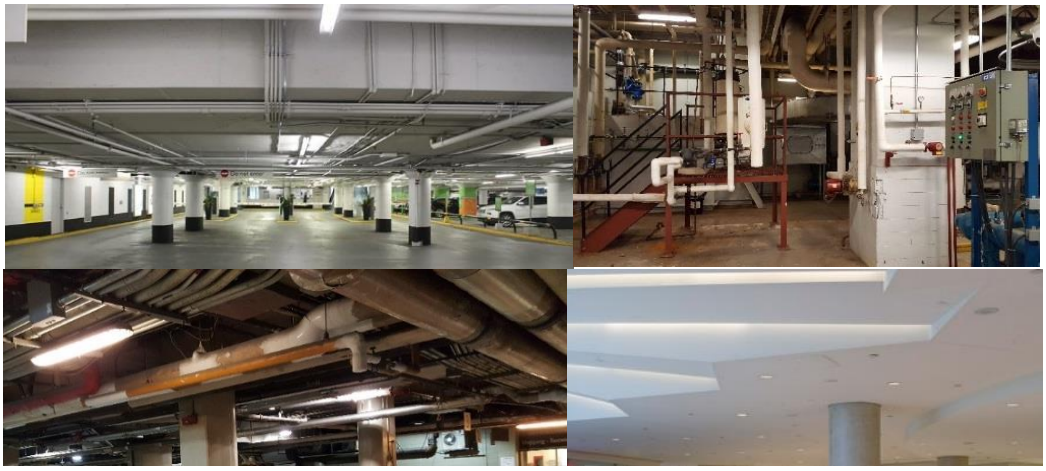
Lesson Learned #1

The importance to identify project goals and establish expectations.

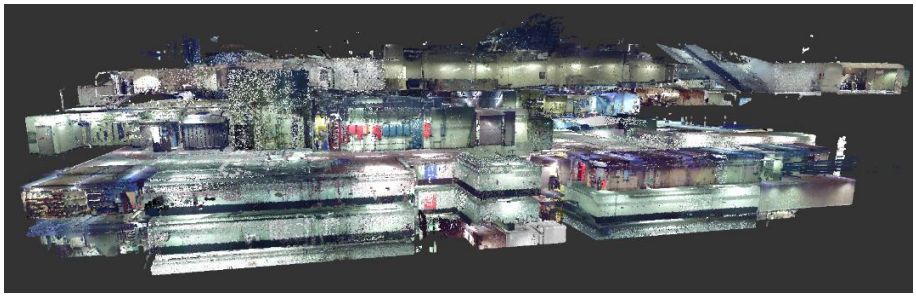
Driven by our commitment to do great work and to meaningfully improve the wellbeing of our communities and built environment, DIALOG aims to create and deliver quality project with consistency and accuracy by leveraging the latest technologies and capabilities of Scan-to-BIM process. Given the vastness and complexities of the existing conditions of the case study site, we understood the importance to engage a professional reality capture consultant who can provide expertise in documenting as-built conditions with precision. Particularly for adaptive-reuse development, the success of this type of project often builds on a strong foundation of accurate, intelligent, and accessible as-built survey.

Identifying Project Goals

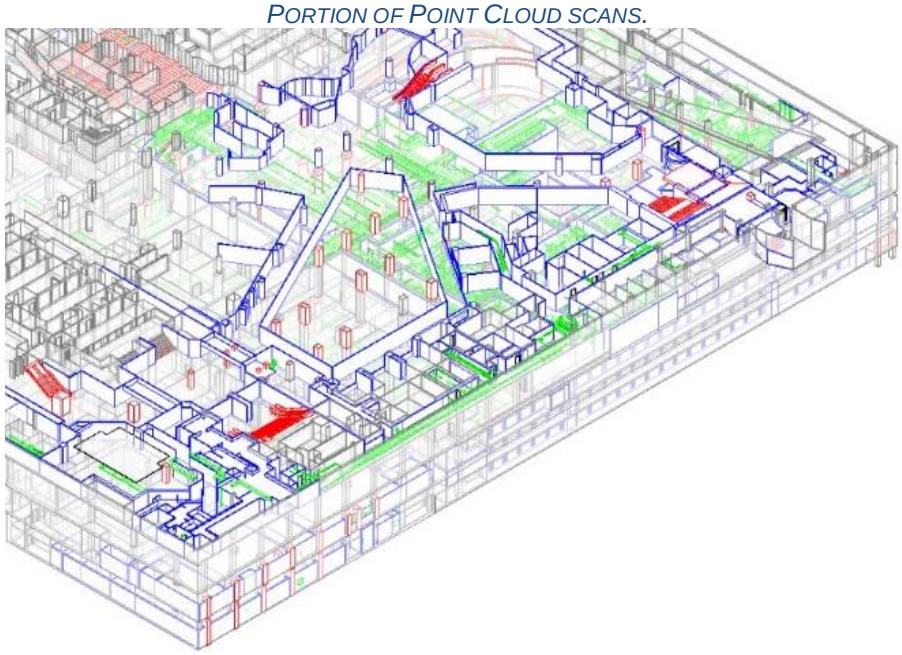
It is important to identify project goals at the onset of a Scan-to-BIM process. This allows both reality capture consultant and architect to agree and aspire to common goals and/or outcomes. As previously mentioned, the case study project utilizes Scan-to-BIM process to accurately document all below-grade levels inclusive of all existing commercial retail spaces, building service spaces, as well as parking lots. In order to seamlessly integrate the existing conditions with the redevelopment of the project, it is determined that LOD 200 Revit models will be produced from scan data collected on site. These scan data along with the as-built models then become the base files for future development.



EXISTING CONDITIONS: LARGE AMOUNT OF STRUCTURAL, MECHANICAL AND ELECTRICAL COMPONENTS, AND COMPLEXITY OF INTERIOR GEOMETRY.



PORTION OF POINT CLOUD SCANS.

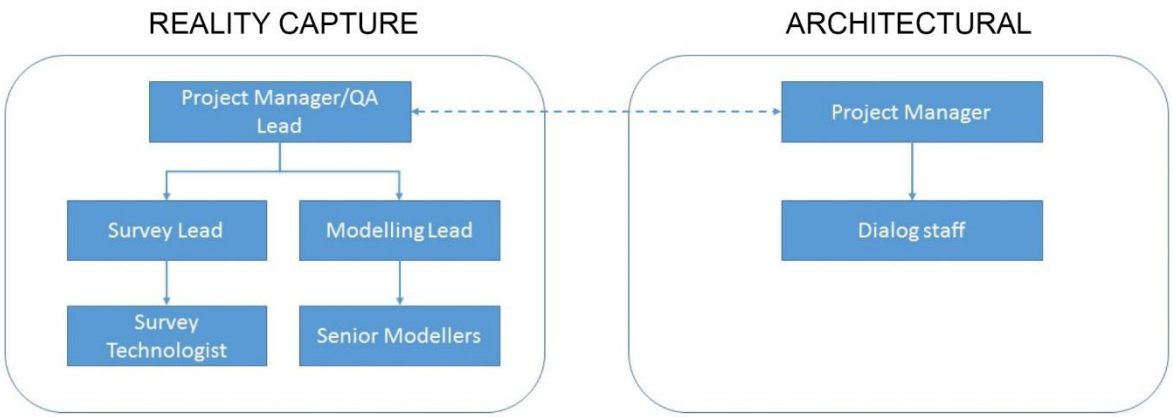


REVIT AS-BUILT MODELS.

Establish Expectations

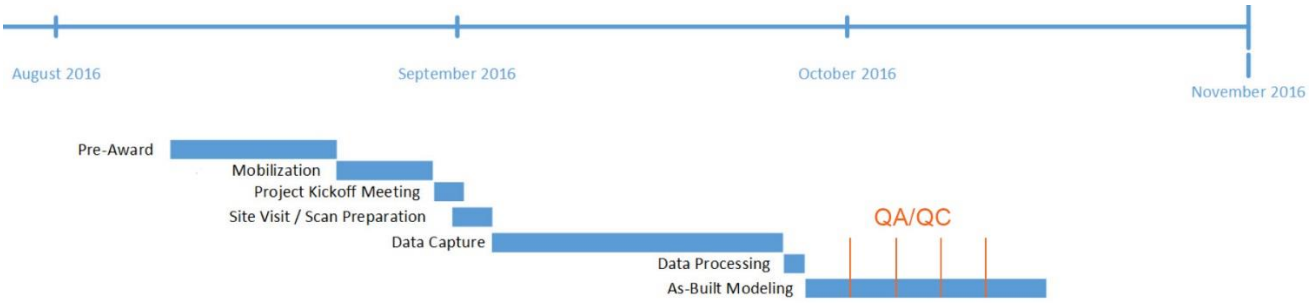
The LOD 200 architectural, structural, and MEP as-built models along with Point Cloud data in colour and photospheres are the final deliverables for this case study. Prior to commencing site scans, a few key expectations are established in order to manage and expedite process effectively between SolidCAD and DIALOG. Aside from an agreed cost as per the scope of work, the following items are identified at the onset of the project as part of the contract:

- Extent of areas that are to be surveyed, and also areas that are NOT to be surveyed: Given the complexity of spaces and the large number of rooms that are to be surveyed, it is important to identify a clear definitive work extent specifying areas to be scanned and vice versa.
- A site walkthrough lead by architect with the consulting team to understand the scope of work: Visual and physical experience of space allows team to appreciate and understand the actual scope of work and site constraints that are inherited from existing conditions.
- A straightforward organizational chart indicating point of contacts between offices: A clear and simple organizational chart with single point of contact if possible can expedite process and ease of communication.



ORGANIZATIONAL CHART.

- Project schedule indicating milestones and quality checking sessions.
  A streamline approach to quality assurance and control can ensure the accuracy of final surveys.



MILESTONES AND SCHEDULE.

- The definition of LOD 200 and BIM survey specification.
  A written document that all parties can agree and rely on regarding modeling details and specifications of the final products.

Lesson Learned #2

A BIM survey specification and guide that is tailored to project goals and deliverables.

It is of the utmost importance to have a binding document that specifies the survey of the project in BIM environment. The document can assist all those connected with the procurement and production of BIM as-built models. While it is understood Scan-to-BIM is a process, the document specifically details the methodology and workflow for creating models of the existing conditions that are tailored to the case study project. The information below highlights some of the major items that shall be specified in the document for considerations relating to parametric BIM modelling.

Level of Development – What to include and exclude from the model?

Aside from the extent of work identified at the onset of the contract, it is useful to have an itemized list outlining the components relating to each discipline that are to be included in the final model. Information is categorized based on model element types, including a brief description of the model element, as well as the respective discipline of the element.

	Model Element Breakdown		3D Modeling	2D / 2.5D Drafting	Graphic	LOD	MEA	Notes
A	SUBSTRUCTURE							
	Foundations							
		Standard Foundations	√			200	ST	
		Special Foundations						
		Slab on Grade	√			200	ST	
		Depressions / Steps in Slab on Grade	√					
	Basement Construction							
		Basement Excavation						
		Foundation Walls	√			200	ST	
		Brick Ledges in Foundation Walls						
		Openings in Foundation Walls (Except Sleeves)	√			200	ST	
		Openings in Foundation Walls for MEP	√			200	ST	
	Pits & Trenches							
		Elevator Pits	√			200	AR	C/M by ST
		Escalator Pits	√					
		Sump Pits	√					
		Trenches	√					
B	SHELL							
	Superstructure							
		Floor Construction	√			200	ST	
		Roof Construction	√			200	ST	
		Slab Depressions / Steps	√					
		Openings in Slabs (100mm and Above) (Except Sleeves)	√			200	ST	Coord. w/ AR
		Openings in Slabs for MEP (100mm and Above)	√			200	ST	Coord. w/ MEP
		Columns / Posts	√			200	ST	
		Beams	√			200	ST	
		Openings in Beams for MEP (100mm and Above)	√					
		Trusses	√			200	ST	
		Bearing/Shearing Walls	√			200	ST	
		Openings in Structural Walls (100mm and Above) (Except Sleeves)	√			200	ST	Coord. w/ AR
		Openings in Structural Walls for MEP (100mm and Above)	√			200	ST	Coord. w/ MEP
		Concrete Curbs / Parapets	√			200	AR	
	Exterior Enclosure							
		Exterior Walls	√			200	AR	
		Curtain Wall System	√			200	AR	
		Exterior Windows	√			200	AR	
		Exterior Doors	√			200	AR	
	Roofing							
		Roof Coverings	√					
		Roof Openings	√			200	AR	
C	INTERIORS							
	Interior Construction							
		Partitions	√			200	AR	
		Interior Doors	√			200	AR	
		Fittings (Washroom Acc., etc)	√					
		Railing	√			200	AR	
	Stairs							
		Stair Shafts	√			200	AR	C/M by ST
		Stair Construction	√			200	AR / ST	Duplicate / Coord w/
		Stair Finishes		√	√			
		Stair Railing	√					
	Interior Finishes							
		Wall Finishes		√				
		Floor Finishes						
		Ceiling Grid	√					
		Drop Ceiling	√					
		Ceiling Finishes						
D	SERVICES							
	Conveying Systems							
		Elevators & Lifts						
		Escalators & Moving W						

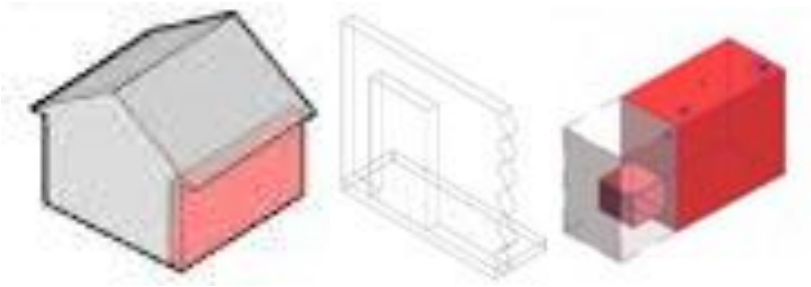
SAMPLE OF DETAIL CHECK LIST.

Level of Detail (LOD) – How will each component be visually portrayed in the model?

The LOD specified in the case study project is 200. As previously described in the presentation, it is critical to understand the different LODs and their definitions. The following is a recap of LOD 200 as defined by BIMforum.org:

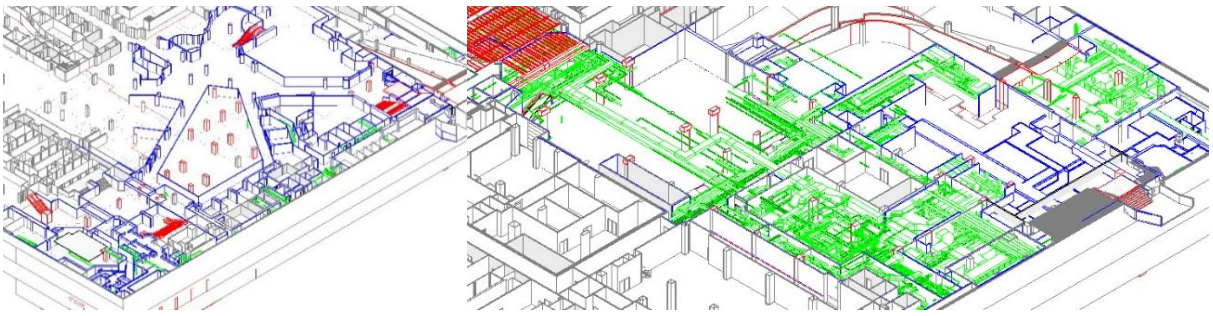
"LOD 200 The Model Element is graphically represented within the Model as a generic system, object, or assembly with approximate quantities, size,

shape, location, and orientation. Non-graphic information may also be attached to the Model Element."



LOD 200 FOR ARCHITECTURAL, STRUCTURAL, AND MEP COMPONENTS

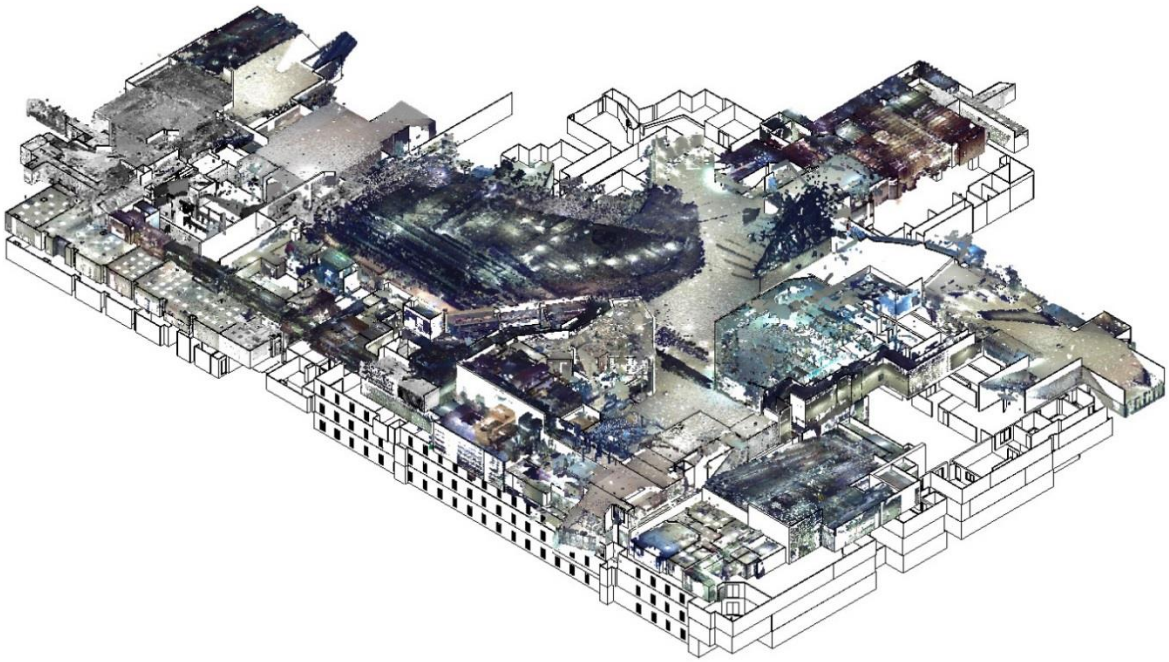
Our LOD 200 as-built models contain major architectural, structural, and MEP components of the case study project including interior ceilings and partitions, floor slabs, columns, beams, openings of doors and windows, major MEP services, and fire protection components. It is essential to define the level of model detail and model information to be shown in the survey. The nature of the project as well as its early phase of redevelopment have led us to agree on the level of interpretation and simplification to represent the existing conditions at LOD 200. Survey models at LOD 200 typically allows for greater adaptability and flexibility when it comes to adaptive reuse project in existing conditions. It allows the model to evolve and grow as the project develops. The size, thickness, geometry, locations, and quantities of building components are all identified in the as-built models. It is imperative to agree modelling methods to be used per component in the project. This is to minimize any re-work of the final deliverables that may incur additional cost or delay to the project. A general rule of thumb is to always model any building component as close to its original function as possible utilizing the same Revit System Family – a floor will be modeled using Revit System Family: Floors etc. Appropriate levels and references should also be set up properly prior to modeling. This is to ensure all components are referenced to their respective levels accordingly. In addition to the survey models, one of the significant benefits of laser scanning is that the team can revisit the Point Cloud data at any time to extract further information as required.



COMPONENTS IN AS-BUILT MODELS.

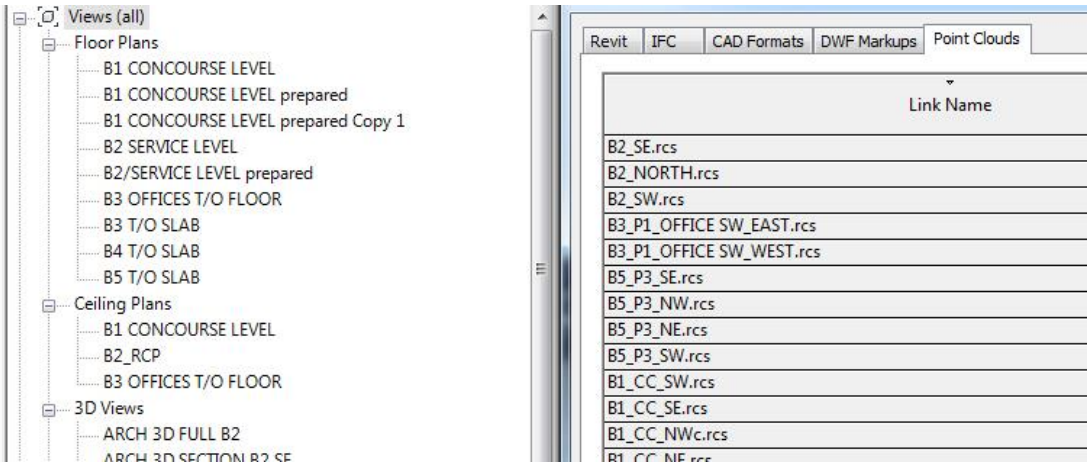
Accuracy of Point Cloud data to the model and file organization

Prior to commencement of the survey, we have established the model accuracy and tolerance required for the project to be +/- 10mm of the actual size and location of building component. Given the high density of points in the Point Cloud data, the interpretation of the building components must be best fit to the Point Cloud data with any measurements rounded to the nearest 5mm to maximize accuracy. Owing to tolerance requirement, the model data constructed to this high-level tolerance only deviates from the Point Cloud scans by the tolerance allowed. As a result, the survey models are as accurate and current as they can be as per the laser scanned data. The team can also reference back and forth between Revit models and Point Cloud data at any given time. This instills confidence in the team when validating as-built conditions, and at the same time maximizing workflow efficiency and reducing carbon footprint by not having to physically go to site.



POINT CLOUD DATA OVERLAYING ON REVIT AS-BUILT MODELS.

With large amount of Point Cloud data and Revit modelling files, it is easy to misplace or misalign information. Therefore, it is essential to manage and organize the file utilizing project browser, workset, views, naming conventions, reference levels to keep information as clear and simple as possible. We have to keep in mind the as-built 3D survey also needs to work for the production of plans, sections, elevations and any 2D views or drawings. Here are some of the examples of file organization from our case study project:



CONSISTENT NAMING CONVENTION IN ALL VIEWS AND POINT CLOUD DATA.

ARCHITECTURAL WORKSETS

WORKSET NAME	DESCRIPTION
AR_Base Building	Core, shaft, stairs, elevators, escalators, ramps, slabs, mechanical / electrical / elevator rooms, etc.
AR_Ceiling	All ceiling components
AR_FFE	Finishes, furniture and equipment
AR_Interior Layout	Interior elements such as partitions, doors, windows, washroom layouts, plumbing fixtures, ceiling, etc.
AR_Millwork	Millwork
AR_Rooms	Rooms, areas, room separation, area boundary lines and scope boxes
AR_Shared Levels and Grids (Primary)	Primary Shared Levels and Grids such as top of floor etc
AR_Shared Levels and Grids (Secondary)	Secondary Shared Levels such as underside of ceiling etc
AR_Workset1	Elements that have not been assigned to a new workset
X_Link_Revit_EL	Electrical Revit model link
X_Link_Revit_ME	Mechanical Revit model link
X_Link_Revit_ST	Structural Revit model link
X_Link_PointCloud	All Point Cloud Scans

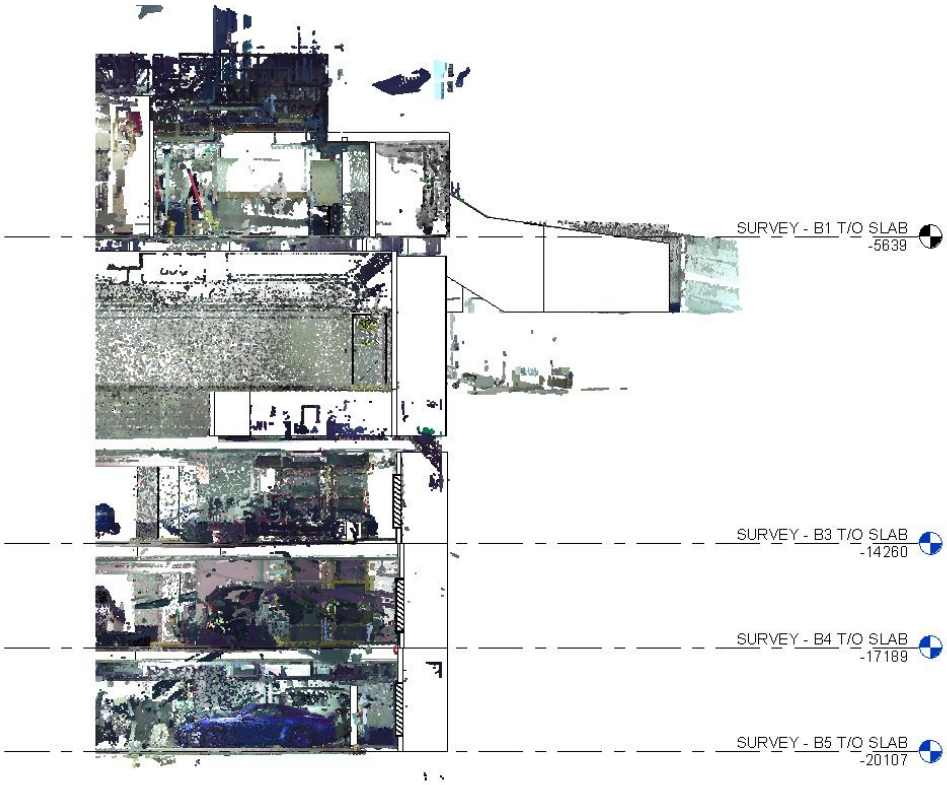
STRUCTURAL WORKSETS

WORKSET NAME	DESCRIPTION
ST_Structural	Structural walls, foundation, columns, slabs, beams, framing, etc.
ST_Shared Levels and Grids	Shared Levels and Grids
ST_Workset1	Elements that have not been assigned to a new workset
X_Link_Revit_AR	Architectural Revit model link
X_Link_Revit_EL	Electrical Revit model link
X_Link_Revit_ME	Mechanical Revit model link
X_Link_PointCloud	All Point Cloud Scans

MECHANICAL WORKSETS

WORKSET NAME	DESCRIPTION
ME_Shared Levels and Grids	Shared Levels and Grids
ME_Equipment	All mechanical equipment

PREDEFINED WORKSET NAMES AND DESCRIPTIONS IN AS-BUILT MODELS FOR ALL DISCIPLINES.



PREFERRED MODELLING TECHNIQUE IS TO MINIMIZE AMOUNT OF REFERENCE LEVELS BY DEFINING ONLY THE ONE REFERENCE PER FLOOR WITH NAMING CONVENTION. IN THIS CASE, ALL LEVELS THAT ARE BY REALITY CONSULTANT IS NAMED WITH PREFIX "SURVEY".

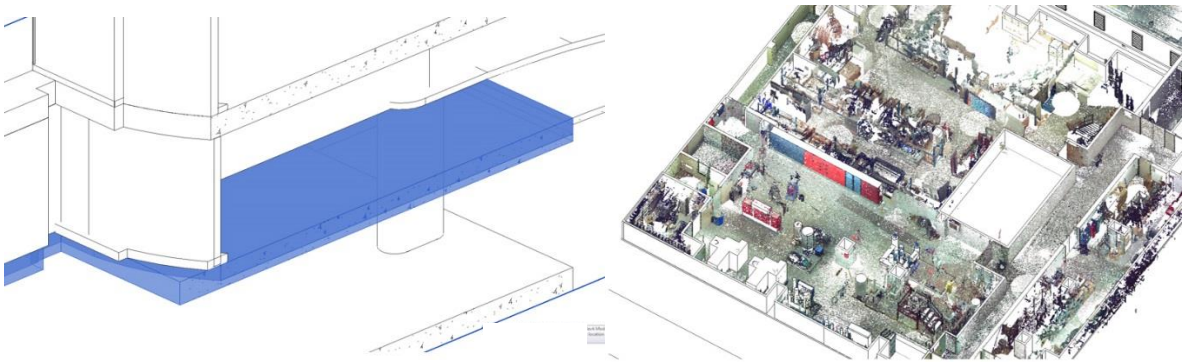
Lesson Learned #3

Quality checking procedures to ensure project quality and accuracy

The Scan-to-BIM service provided by the reality capture consultant has included QA/QC procedures in their own production process. In addition to their own quality checking, we have also scheduled several quality assurance and control sessions between consultant and architect throughout the production of the survey models to ensure the survey BIM models align to the predetermined specified requirements. Real-time quality checking session is particularly useful when teams are working remotely from different geographical locations. Teams can orbit models in real-time and highlight aspects of model that are in questions or require further review. The following is a list of quality assurance practices that are implemented in the checking procedures:

- Geometry check of progress models issued by consultant. Primarily checking model components and the correct geometry have been modeled and are in the right place in relation to the point cloud.
- Components are modelled to the specified Level of Details.
- Model accuracy is within project tolerance.
- Models of different disciplines are constructed in a consistent manner as per the BIM survey specification and guidelines.

- Naming conventions are correct and all reference levels, family naming, as well as component naming are per BIM survey specification.
- Warnings in Revit models are fixed and reduced to the minimum.
- Any unnecessary levels, views, other project parameters are deleted and purged from file.
- Final Revit files are detached from central.



ACTIVE VIEWING AND ORBIT IN MODEL ENVIRONMENT TO PERFORM QUALITY CHECKING.

Lesson Learned #4

Data exchange and interoperability between software and platforms

The final deliverables for this case study project is BIM survey models, Point Cloud scan data, and colour photography of the scanned site. Given the large amount of files and data, it is essential that the version of software is the most current and interoperable between platforms. The BIM survey models for the case study project are delivered in Autodesk Revit 2017, with the capability to export to a number of other formats including iFC, NWF, DGN, DWG and VWX. The raw scan data are Point Cloud files that can operate in applications such as Revit, AutoCAD, MicroStation and Navisworks. The laser scan data with colour photospheres can be viewed in Autodesk ReCap or other web-based viewing portals for additional information of site conditions.

For handling the large amount of data exchange and transfer for the case study project, DIALOG has set up and hosted a project specific FTP with login requirements. All progress and final file uploads are clearly dated and organized on FTP to ensure all parties utilize the most up-to-date data. This has maximized efficiency and reduced risk and cost in creating a set of coordinated information. Being aware of the different softwares being used will assist in the ability to control of large data exchange and optimize interoperability between various platforms.

A simple and straightforward BIM survey specification where basic parameters, file formats, data exchange platform, point of contacts, LOD, views and naming conventions are defined will provide guidance to the user of the BIM-ready survey models. Any user can reference back to the specification to understand the setup of the file, Point Cloud links, as well as to navigate within the BIM-ready survey with ease in understanding and extrapolating as-built information. The easier to navigate and understand the survey models, the easier for the client or any consultants to understand the existing as-built conditions. Especially with adaptive reuse project that project longevity and life-cycle management are important factors for the client, a set of detailed, precise,

adaptable 3D survey models are definitely an asset and valuable to potential future development. We hope we have demonstrated to you how our 7-trillion point BIM case study has produced accurate, intelligent, and accessible 3D surveys for both users and client.

Conclusion

From the role of 3D scanning in today's modern AEC firms, to all the technical know-how of the Scan-to-BIM process, and the collaborative effort between reality consultant and the design team, we hope we have demonstrated to you through this case study project some of the major benefits and best practices of a laser scanned BIM-ready survey. Laser scanning technology coupled with Scan-to-BIM workflow is definitely a great new tool and solution in capturing existing as-built conditions with accuracy. The more AEC firms leverage this technology and tool, the better the quality and the more affordable of a BIM-ready survey in the industry for all sizes of companies.