Beyond Clash Detection: How General Contractors can use BIM on Any Project

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Learning Objectives

- Identify which technologies and processes will best benefit individual projects
- Learn about the various technologies that can be integrated into construction projects
- How to engage non-BIM users in the construction process
- How to Earn Client Buy-in into the BIM Process

Description

BIM (Building Information Modeling) has been a buzzword in the architecture, engineering, and construction industry for years—and yet the construction industry as a whole has been slow to adopt the BIM process. In this session, we will investigate the software and processes used by a single construction company to deliver powerful services to our owners, consultant teams, and trade partners. Learn how to integrate technologies such as 4D scheduling/animations, 3D laser scanning, virtual reality mockups, and 360-degree cameras into your projects—improving overall communication and coordination. This presentation will discuss Revit software, ReCap software, Navisworks software, and Autodesk Rendering, with examples of projects that used virtual design from start to finish, as well as projects that benefited from BIM in select areas of the project. The session will summarize a construction company’s BIM journey from BIM-free to BIM as often as possible, on all stages of a project.

Speaker

Kate Kirwan is the VDC Manager for Turner Construction Company in Canada, and a member of Turner Vancouver’s Senior Leadership Team. Her international work in the AEC industry began in Dublin, Ireland, where she worked as a conservation architect for the Irish government before moving to Canada in 2010. Her experience encompasses various construction types including complex new build programs, renovations, and highly technical M&E builds. Kate works to promote BIM use throughout the AEC industry in Canada and has collaborated with and presented to numerous consultant groups and organizations and at conferences such as BuildEX Vancouver and LCI-Canada.

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Definitions

Below are our definitions of Building Information Modelling (BIM) and Virtual Design and Construction (VDC). These definitions are key to the approach and methodology we use in Canadian Turner Construction Company.

Building Information Modelling (BIM)

We define the Building Information Model as the model of an individual system, be it architectural, structural, mechanical, electrical, plumbing or fire protection.

Virtual Design and Construction (VDC)

Virtual Design and Construction is the process of managing all the individual 3D project models, or BIM, for the entire lifecycle of the project. This includes the very initial planning stages through to project completion and building management.

Current State: The US vs Canada

Canada is behind many parts of the US in terms of the application of BIM and VDC. In my opinion, this is due in no small part to the refusal by the Canadian government to require building information modelling on public projects. This is applied in the interest of fairness, allowing companies who may not have the resources to invest in and implement BIM in their company. However, in many cases, and again in my personal opinion; this is redundant as many smaller or less financially able companies do not have the resources to work on large-scale government projects and so will most often not be involved in projects where BIM is of major benefit to the project.

Whatever the reason for the difference in BIM provision between the two countries, it is a reality that often on projects in Canada, we receive 2D AutoCAD drawings only, particularly from the mechanical, electrical, plumbing and fire protection (MEPF) sectors. It is also a reality that often our trade partners will not provide models or drawings in any capacity, and that the consultants only will provide these services, although this is more prevalent on the West Coast of the country than the East.

This lack of BIM provision informs the way we approach our projects, and the VDC services we offer in the Canadian market.
Our Software Toolkit

The following software programs are part of our standard toolkit at Canadian Turner Construction Company – we have built up this library over the past few years with testing and as project need arises.

- Autodesk AutoCAD
- SketchUp
- Autodesk Revit
- Autodesk 360
- Autodesk Rendering
- Autodesk Navisworks
- Various plug-ins, such as iConstruct for Navisworks
- Adobe Design Suite
- Autodesk Recap Pro
- Synchro Software
- Lumion
- Holobuilder
- IrisVR
- InsiteVR
- Trimble Realworks
Learning Objective One: Identify which technologies and processes will best benefit individual projects

Know your audience. What are you trying to convey? What are you trying to achieve with your drawings and models?

Establishing the project requirements early on in the project are key to successfully implementing the VDC process. When we review the VDC implementation plan for our projects, we identify the target audience of the work we are required to provide. The technology and software we employ depends on the construction knowledge and technological capabilities of our audience.

For example – our clients generally do not have a good working knowledge of 2D drawings. We can lose sight of this, having read complex 2D drawings for many years on a daily basis. The images below illustrate the power of 3D models, and how complex information can instantly become easier to understand and more relatable in a 3D context. Figure 2 below is a 2D site logistics plan, outlining the planned crane swing impact, access roads for site works and deliveries, planned site trailer locations and man hoist requirements. While the 2D image could be enhanced with the addition of text and arrows outlining the various components, it is not an image that clearly conveys the magnitude of the site works, particularly to someone who is not used to reviewing drawings from a two-dimensional point of view. Figure 3 is the exact same image, taken from a 3D perspective. The viewer can now appreciate the scale of the construction site in context with the surrounding area.

Figure 2 - 2D Site Logistics Plan.
Photo credit; Turner Construction
How much time and how many resources do you have?

Another consideration when determining what technology should be applied to a project is the amount of time you have to complete the work. Having a fully coordinated model for a project is wonderful – unless the construction schedule is so tight that you don’t have the resources and information required to get the model ready at such a time when the information is actually of use for the project. In this area, communication is key. Time also dictates the quality of the work output. Consider the two screenshots on the following pages, Figures 4 and 5, taken from two different animations created for project pursuits.

*Figure 4* is an image taken from an animation created using scenes in SketchUp. For this hospital project, the VDC Department was asked to produce an animation of one of the project’s eighteen construction phases. This animation had to demonstrate to the client the impact of construction on the main entrance to the hospital and convey our understanding regarding maintaining patient, emergency vehicle, staff and visitor access during the course of construction. We only had three days to produce the model, one VDC modeler available to do the work, and they were located on the other side of the country in relation to the project. An added complication was that the project drawings, which were only provided in PDF at that stage, related to the interior works and only showed the outline of the exterior of the building. There were no exterior elevations. How were we going to model the exterior of a building from the other side of the country in three days?
The answer was Google Earth. The modeler “walked” up and down the street from the comfort of their desk, modelled the surrounding area and matched materials from the building as per the Google Earth images.

The resulting model allowed us to provide a rudimentary, albeit recognizable, animation showing the maintenance of building access, emergency service parking and patient drop-off zones, along with our hoarding plan and clear way finding signage. The client was able to recognize their building, and better able to understand our plan than if we had put marked-up 2D drawings in front of them. After we won the project, the hospital representatives asked us to create more models as construction progressed. We produced multiple interior animation videos demonstrating the impact of construction on the day-to-day operations of the hospital.

Figure 5 is an image taken from a pursuit model created using Revit and SketchUp models which were imported into Lumion. Additional Lumion elements were added, scenes were created and the animation was rendered in the program. The VDC team had 8 days to produce this model, with two staff members assigned. The project drawings were available in PDF only, but with more manpower and more time, we were able to produce a more detailed animation with a higher graphical standard.
What Resources do you Have?
The final consideration, and perhaps the most important one, is the budget available to complete the work. This budget incorporates not just the software used, but also any training required and the time required to complete the work, as per Figure 6.
What can you do with the software you currently have access to, and will it provide what you need for the project? Turner’s Software toolkit, as shown on page 2 of this document, contains 15 different programs, with an estimated cost per annum of $11,500 USD per person for our four person team. Bear in mind that this cost does not repeat in full on an annual basis – programs like Lumion and Trimble Real Works are a one-off cost unless upgrading a newer version. The calculation in Figure 6 also divides the cost of a single or shared license into four, to account for our team.

*Figure 4*, the image from the hospital project animation video created in Lumion, was created by one modeler in three days, with SketchUp, an inexpensive program, and Google Earth, which is free. The animation shown in *figure 5* took two modellers 8 days to create, using Revit, SketchUp and Lumion software. It also required a high-powered laptop with an excellent graphics card to create a top-quality animation. Not only are you paying for the software and the laptop, you have to factor in 128 hours of salary paid to the two modellers. All of these factors are important to consider when deciding what to integrate into your construction projects.
Learning Objective Two: Learn about the various technologies that can be integrated into construction projects

There are a number of technologies that can be incorporated into the construction process. This section will focus on the most common technologies we integrate into our projects – 3D laser scanners, 360 degree cameras and virtual reality models. We provide all these services in-house rather than outsourcing, which allows us to control the final product, and quickly make changes if requested.

3D Laser Scanning

3D laser scanning is a non-contact, non-destructible technology that captures a physical objects exact size and shape in the form of a digital three-dimensional representation. There are three types of laser scanners – short range, mid-range and long range. Short range scanners are typically less accurate than mid to long range scanners as they use laser triangulation rather than the pulse-based or time of flight method of medium to long range models. Laser scanners are based on the speed of light concept – if the length of time a laser takes to reach an object and reflect back to the sensor is known, then the distance of the object from the scanner can be calculated.

Each scanner model will specify their maximum range, or scan density, however it is imperative not to rely on the extents of these boundaries for accurate data capture as the further the distance, the less accurate a scan will be. Typical scan settings for a large area are set to a point density of 3mm at 10 meters. This means there is a point spacing of 3mm between each point at a distance of 10 meters. When the scanner is moved outside the 10 meter range, the distance between each point increases, so that at 20 meters the distance between each point is 6mm. The lower the point density, the less detailed a scan will be.

It is important to remember that 3D laser scans can only see what the naked eye can see – they cannot x-ray or see through anything! Generally, multiple scans are necessary to capture all the data required. These scans must be pre-aligned in a common frame (either manually or with the laser scanners’ inclinometer) and overlap one another. The scans must be “stitched together” or registered later to create a comprehensive point cloud of the entire project. To facilitate this registration, targets, spheres or a mixture of the two are used in the field. A minimum of three common targets or spheres are required between adjacent scans – I like to have at least 5 common points to guarantee I can properly align the scans with one another.
We first used 3D laser scanning on a law firm project in downtown Vancouver. This project was a tenant improvement project, within a 7 storey building dating back to 1973. The building was completely stripped back to original structure and split into a number of units – a Nordstrom department store, offices for Microsoft and Sony ImageWorks, and the 40,000 square foot Miller Thompson law firm office on the 4th floor. We received base building AutoCAD files from the landlord, and the project interior designers created a Revit model based on the information contained within these files. The designers requested some dimensions from site, and the project coordinator and I went to take these measurements. We quickly realized that there were major discrepancies between the as built drawings provided by the landlord and the actual conditions on site.

We had access to the site a couple of months before construction began, which really helped as there was only one person available at the time to do all the scan-to-BIM work. We persuaded the owner to pay for the scanning, and using a Faro X330 3D laser scanner we completed 268 full colour scans in the space of 7 days. It took 3 weeks total to combine these scans in Autodesk ReCap Pro, bring them into Revit and model the existing conditions. Figure 8 on the following page outlines the scan-to-BIM process. The completed 3D model revealed information critical to the success of the project; the perfectly aligned, 30” diameter columns shown on the base building drawings actually ranged in size from 26.5” to 31.5” in diameter, and they certainly were not in a straight line. This knowledge saved a lot of time and rework for the project, as there was custom pre-manufactured planters and seating wrapping around these columns. The large duct shown in Figure 8 was undocumented, and went straight through the planned mezzanine loft space. We decided to relocate the loft rather than re-route the mechanical system. Raised access flooring was specified across half the area of the office space, and we discovered that the height of this raised access flooring conflicted in parts with the perimeter ventilation boxes used for heating and cooling. Customised office pods imported from Italy had strict tolerances with regard to floor flatness, and our floor wasn’t flat! By using Trimble RealWorks, we were able to analyse the floor “levelness” and resolve any issues weeks before the system arrived from Europe.
The exterior walls of the office space were made up of a glazed curtain wall system. When we initially modelled from the 3D laser scans, we didn’t model the curtain walls. However, when our drywall trade partners began to lay out their wall locations on site, we realized that the meeting room walls, laid out along the perimeter of the office, were defined by the window mullion locations. These locations were based on the landlord’s drawings. As a result, every single perimeter wall location had to be revised. Rather than having the site team work to figure out a layout, calculate the new volume of each room and quantify the change required to the interior designer, we were able to go back to our original scans. An exercise that would have taken a couple of days to figure out on site only took a few hours to resolve. We modelled the actual window mullion locations, laid out the new wall locations, and created drawings for approval by the design team within a 4 hour timeframe.

Since this first project, we have completed the scan-to-BIM process in-house on a number of different projects across Canada. We began with renting our scanners from a third party, and in February 2018 purchased a Leica BLK 360 scanner. Depending on the project requirements, we use Faro total station scanners or our BLK 360 unit to complete the scans.
360 Degree Cameras

360 degree cameras are omnidirectional cameras with a 360 degree field of view. Essentially, a view in every direction is recorded within a single image. At Turner Construction, we use 360 cameras for numerous reasons – to document construction progress for our owners, to capture existing conditions and to create a digital portfolio of our work.

We take 360 degree images with either our Samsung Gear 360 camera or our Ricoh Theta V camera and upload them to Holobuilder, a cloud-based software that allows us to create virtual tours of our sites. We use Holobuilder because it is easy to share the images and easy for the end user to navigate.

Virtual Reality (VR)

Virtual reality is a computer-generated immersive experience within a three-dimensional environment. A person using virtual reality equipment is able to "look around" the artificial world, move around in it, and interact with virtual features or items. We share out VR models across a number of different platforms, and we create all our VR models in house using a number of different software programs.

As shown in Figures 2 and 3 of this document, complex information can instantly become easier to understand and more relatable in a 3D context versus a 2D one. We create and use virtual
reality models to deepen understanding of a particular project element, such as a virtual model of kitchen millwork, for example; or deepen understanding of a project space, such as the layout of the entire kitchen.

The Watson Goepel law firm project is one such example. This tenant improvement, or fit out, project is located in downtown Vancouver, and a team of 9 partners from the firm formed a steering committee in charge of approving the design decisions. The interior design team created beautiful, detailed look books for the project to complement their 2D AutoCAD drawings, but given that the lawyers were unused to reading 2D drawings, they were having trouble visualizing the space. This was causing delays to our construction schedule.

To help the client understand the design and expedite their decisions, we decided to model key areas of the project. These areas included the reception area, the client kitchen, main boardroom, private offices and interstitial meeting rooms and one of the open office areas. We worked closely with the interior designer, who provided all information relating to the textures and finishes of the office, and created incredibly detailed Revit models. Using the exact material specifications from websites and catalogues, we produced custom families of every single component in the chosen areas; manipulating images of the finishes in PhotoShop to produce seamless textures. We rendered the models in the cloud with Autodesk Rendering.

When we shared the VR models with the steering committee, they were immediately able to understand their new office. They signed off on a particularly expensive piece of millwork in the client kitchen that had been holding up construction, changed the height of cabinets in the open office from 6'-0" high to 4'-0" high to maintain clear lines of sight, and changed the custom-designed reception desk from round to rectangular, Figure 10.

![Figure 10 - Evolution of the Reception Desk at Watson Goepel](photo-credit-turner-construction)
Learning Objective Three: How to Engage non-BIM Users in the Construction Process

The non-BIM users that will be specifically addressed in this section include;

- Construction team members
- Owners and end-users
- Consultants & trade partners

We enhance our non-BIM users understanding of the construction process by involving them in a number of activities;

- Technology in the Field
- Virtual Mock-Up Demonstrations
- Virtual Mock-Up Sharing
- Coordination Models
- Coordination Model Sharing

Technology in the Field

When we create models for a project, we share them with our teams via software that is easy to navigate, such as A360, and give them tutorials on how to use the program. 3D modelling is still new to many of our teams in the field. Explaining the capabilities of the models is one thing; giving them the skills to navigate their way through the models makes the process a lot more engaging and relatable. A360 allows you to access the models via your computer or iPad, so our teams can take the models directly on site with them and explain complicated areas or the logic behind a construction sequence to the build team in the field. It also doesn’t cost money to use A360, which the teams really appreciate. We also share our models via Navisworks Freedom (which is free), Navisworks Manage, which allows the team to see clash detection viewpoints clearly, and BIM 360 Glue.

Often, we will set up digital plan tables in the site office or out in the field, so that Turner’s team, our consultants and trade partners can access the project drawings and models easily. Using a digital plan table is an easy way to ensure that everyone is working with the latest set of project drawings.
Virtual Mock-Up Demonstrations

When we create virtual reality models, we need to demonstrate them effectively. While it is helpful to visit a client’s new office and show them what their future new space will look like, it is a lot more effective to demonstrate that on the construction site. We frequently take our owners and end user groups onto our construction sites, walk them to where their future kitchen, private office or laboratory is going to be and give them a VR headset so that they can see what the end product will look like.

To do this, we have found that mobile headsets are most effective. Our current favourites are the Samsung Gear VR and the Oculus Go. They can be used with very little instruction and block out the surrounding environment and daylight so feel immersive. They are made of robust materials so can survive well on a jobsite.

One challenge we initially came up against while using these headsets was that we couldn’t control the user experience; if someone pressed the touchpad on the GearVR and didn’t understand the navigation controls they could exit the project. We have been able to resolve this with InSite VR, an online program that allows you to stream the headset view to your laptop, and control what the user is looking at. This has an added bonus of allowing everyone else in the room see what the user is seeing, so they are not just interested and engaged when wearing the headset.

Demonstrating the future state of the site has the benefit of increasing end user buy-in and excitement about their new space. Many of our clients move from more traditional office settings...
to open-concept, modern spaces that are more welcoming and tailored to employee comfort and productivity.

![Photo Credit: Turner Construction](image)

**Figure 12** - On-site demonstrations to the new occupants increase anticipation and help the staff to understand their new office.

We also demonstrate virtual reality models and mock-ups to our consultants and trade partners. These models can help the team to understand how to build a complex area, or why we have scheduled construction in a certain way.

**Virtual Mock-Up Sharing**

After we have created virtual models and demonstrated them to our clients, consultants and trade partners, we like to share the models with them so that they can reference them in the future and share them with their staff, stakeholders or team. We distribute the model via web links or QR codes, so that the VR models can be viewed on computers and mobile devices. We have created our own custom-designed Google Cardboard headsets that we distribute. This creates a more immersive experience, and is helpful for promotional purposes too!

**Coordination Models**

We share coordination models with our consultants and trade partners. These models are generally of complicated areas, and we produce a variety of 3D views and 2D drawings to
explain them. For example, one of our projects is a power plant that involves the installation of three one hundred and thirty foot high chimneys. These chimneys are supported by a five foot deep concrete slab filled with rebar, and there are custom-built metal “collars” at the base of each chimney with 24 embeds per collar driven into the slab. Details for this area were provided in 2D AutoCAD only, and we were concerned about coordinating the rebar arrangement with the embeds. We took the structural engineer’s shop drawings and modelled them in 2D, clash detected the embeds versus the rebar and made recommendations for the layout of the rebar on site. Once the structural engineer had reviewed and approved our design, we colour-coded the model to clearly identify the different sizes and shapes of rebar to be installed in the slab.

![Figure 12 - Coordinating Complicated Construction](image)

*Photo Credit: Turner Construction*

We produced 2D plans outlining the top and bottom rebar mats in colour with the legend to explain construction, we created 3D views with call-out text to explain the various components of construction, and we uploaded our model to A360 so that the trade partners could view the model themselves, selecting individual elements to learn more about the properties of those elements. Before sharing all this information, we held a meeting on site with a tutorial on how to access and understand the information.

**Coordination Model Sharing**

As previously outlined in the “Technology in the Field” section, we share these models via A360, Navisworks Freedom or Manage or BIM 360. We have created simple to use step-by-step guides about navigating the programs, which we share after demonstrating how to use the programs in person.
Learning Objective Four: How to Earn Client Buy-in into the BIM Process

Given that understanding and implementation of BIM and VDC in Canada is generally much lower than in the United States, we continue to work to educate our clients (and often, our consultants and trade partners) on the services we can provide and the benefit that VDC brings to the construction process.

Communication is Key

Very often, our clients have misconceptions about building information modelling. We see client education as an important part of the VDC department’s role in Canada. We aim to clarify the possibilities and the limitations of the VDC process, demystify the terminology surrounding the industry and explain the process of applying virtual design and construction to their project.

Below are some of the methods we employ to engage our clients, help them to understand the end result of their project and keep them coming back for more.

Send in the Calvary

On projects where VDC will be employed, the VDC department are generally involved from the outset. We form an important part of the project team and we know how to explain and sell the services we provide. Misunderstandings arise when VDC is sold by teams who can’t speak the language and explain the process effectively – in the past, I’ve seen VDC services both under and over sold when our department hasn’t been involved.

You should be able to put your VDC staff in front of the client – at the very least, your VDC Manager must be able to explain BIM in a way that is relatable and easy to understand. We have found that the most effective way to explain VDC is to show rather than tell. Share images, demonstrate virtual reality models, walk through a model or review an animation – VDC is a visual medium, why would you only explain it with words?

Use Local Examples and Case studies

Our clients don’t want to see a project we built in Tennessee – they want to see the one we built in Toronto. They want to meet the team that will be building their project, and see examples of their past work. We can only do that by providing local case studies. We have built a library of case studies for our VDC work in Canada. We don’t use an external marketing team for the case studies. Instead, the VDC team collaborate closely with our in-house marketing team to create documents that are comprehensive yet concise and explain VDC in terms that a layperson can understand.
BIM Champions

For the VDC process to be effective, there needs to be buy-in from the entire project team. We have a number of “BIM Champions” in various roles within the company. These individuals are not directly involved in the VDC department – they are project managers, superintendents and project coordinators who have seen the benefits of VDC on their projects, want to continue to use our services, and want other projects to benefit from the VDC process too.

BIM Execution Plans

BIM execution plans are not just for our consultants and trade partners! While it is incredibly important to define the team deliverables, project schedule and software use for a project, it is equally important to understand and incorporate what our clients require too. We work with our clients to understand their needs and we produce a document that defines our VDC deliverables. This document uses a lot of visual aids and examples from past projects to effectively convey our scope. Having an open conversation with our clients sets their expectations and ensures that there are no misconceptions or misunderstandings.

The client document we create forms the blueprint for VDC component of the project and serves as a reference document for the entire lifecycle of the project.
Follow Through

Just like all other Turner Construction departments, our VDC department endeavors to provide what we promise. We deliver our work to the very best of our ability and aim to go above and beyond every single time. The only way to do this successfully is to clearly communicate the process, define the project deliverables and understand what the end result should look like.

**EXPECTATION**

![Game of Thrones](image1)

**REALITY**

![Reality Example](image2)

*Figure 14 - Communication is Key to Providing the Expected End Result.*

*Photo credit; via @ValentinHochet, Twitter*