ONTARIO GENERAL CONTRACTORS ASSOCIATION

Guide to Construction and Design Technology

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ONTARIO GENERAL CONTRACTORS ASSOCIATION

ACKNOWLEDGEMENTS

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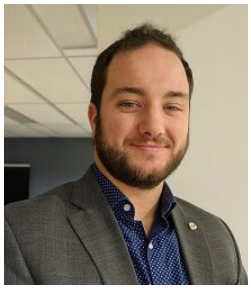

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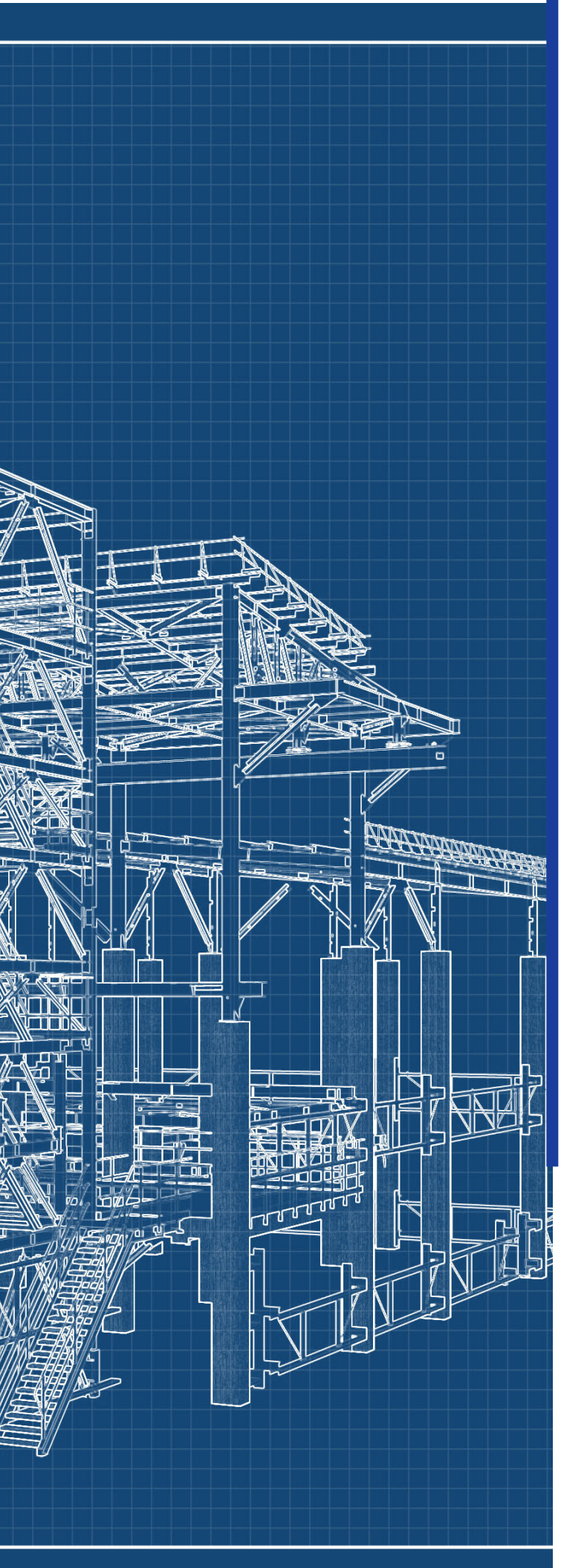


TABLE OF **CONTENTS**

DEAR BIM GUIDE READER

Welcome to the first edition of the Ontario General Contractors Association Guide to Construction and Design Technology.

For more than 82 years, the OGCA has diligently worked to build Ontario by directly assisting our members in delivering construction excellence in the Industrial, Commercial and Institutional sectors. Our members include just over 200 small, medium, and large firms representing contractors' full breadth and diversity in Ontario. This guide is a testament to the collaboration of the construction industry and an essential part of our mission to be a leading advocate for our industry and to foster an improved general contracting environment.

In 2019, the OGCA Innovation Committee created a Taskforce to learn more about digital technology applications for general contractors and subtrades in Ontario. Over the past two years, we have been consulting with subject matter experts on construction and design technologies in construction, specifically regarding Building Information Modeling (BIM), reality capture and geographic information systems (GIS). This consultation, initiated under the leadership of Dorin Nitta of Kenaidan Contracting Ltd. and now led by Tyler Holditch of Matheson Constructors, has resulted in this guide. We believe what makes this guide unique is that it was developed collaboratively and voluntarily across the industry by those using this technology every day.

Throughout the guide's development, we have realized that these concepts are not easily defined due to the rapid change in construction technology. In 2007, BIM was defined as utilizing 3D parametric objects to produce digital models used during the project life cycle. Today, according to BS EN ISO 19650-5:2020, BIM is defined as the process of utilizing appropriate technology tools to deliver the amount of information needed for design, construction, operations and maintenance of projects.

As the adoption of BIM in Ontario continues to accelerate, technology has become essential to delivering a sustainable and resilient built environment. To stay relevant, we believe it vital for general contractors to understand the international standard ISO 19650 and its relation to the construction process. The intent of this guide is to explain the merits of construction technology and provide practical advice about how general contractors can adopt BIM and other forms of technology.

We believe that this guide will help those looking to make investments in BIM by providing a basic explanation of the benefits of investing in this technology and the resources required to use BIM efficiently and effectively.

Organizations across the supply chain can use this guide. We intend to update the guide as BIM, VDC and ICT continue to develop.

Thank you,

Giovanni Cautillo
President, Ontario General Contractors Association

1 CHAPTER 1 INTRODUCTION

The very nature of the construction industry is evolving and this evolution is creating a new set of complexities for which the construction sector needs to be prepared.

One such complexity is in how we manage the vast amount of data that are created with each project. Since each classification of work is highly skilled and rather complex, this may lead to a fragmentation of the work created by professional responsibilities and contractual scope separations in the process of designing and building a structure. As construction projects increase in size and complexity and construction companies also increase in size and dependencies, we are faced with project teams in the hundreds collaborating from different cities, provinces, and sometimes countries. Trying to simplify the process are Architects and Consultants who design, and Construction Managers and Trade Partners who construct. Theoretically, each phase can be completed independently and there are contract methods that support clear scope separations. Some stakeholders believe that these methods are more conducive to financial clarity in the construction process, but statistics have proven otherwise. Project teams around the world are finding ways to increase design and construction efficiencies using two major strategies.

FIRST STRATEGY - COLLABORATION

To share the responsibilities and overlap scope to increase collaboration. A contractual method called Integrated Project Delivery (IPD) is one example where the early input and integration of key constructing partners results in a mature design. The goal of early input is to eliminate unknowns or any uncertainties that may result in an incomplete or highly conservative design. The IPD process ensures stakeholders of the design and construction process work together and make decisions that will affect the detail of the design and the process of constructing. The result is reduced Requests for Information (RFIs) into the design and a design that is reviewed and ready to build. Even constructability changes are integrated into the design, increasing the efficiency in the construction process. IPD is just one of a few examples where a contractual obligation to collaborate can result in efficiency in the design-build process.

SECOND STRATEGY- TECHNOLOGY

Increase communication and collaboration through the use of technology. The fragmented process of designing and constructing can be supported by introducing a Common Data Environment (CDE), which is a central repository of information that can be collected and shared with multiple stakeholders. Now, if the contract permits it, a Constructor can review and analyse the information that is being used to complete the design and provide input. Not only that, next level drafting technology found a way to combine both drawing and specification information into a visual CDE we now call “BIM”. A wall is no longer a rectangle on a piece of paper, it now has properties, materials and compositions that link it to the information provided in the specifications. The information that is linked to model elements within a BIM model is what makes this new documentation process revolutionary.

In this guide we will be focusing on the use of technology to increase efficiency. The following chapters will start from the beginning and define “what is BIM?” A foundation will be created of the concepts that will help explain why adoption of BIM/VDC processes are only increasing worldwide. Once the concept is understood, we can explore how the BIM models are created; emphasising that surveying and reality capture techniques are the foundation of the BIM process, which is what makes the process accurate and reliable. This guide will then touch on what makes a successful BIM project team and provides some points to building a successful project using technology. To finalize the guide, the last chapter will look to the future and explore how BIM and related technologies will evolve as part of the future of how we build.

2 CHAPTER 2 WHAT IS BIM?

BIM is a highly collaborative process that allows multiple stakeholders and AEC (architecture, engineering, construction) professionals to collaborate on planning, designing, constructing and maintaining infrastructure assets.

This is typically done by, and not limited to, utilizing one or multiple 3D models in conjunction with one or more multiple Common Data Environments (CDEs). The process in which this is managed will ultimately determine the successfulness of the project.

The easiest way to understand 'BIM' is to break it down into its separate parts to gain a better understanding of its meaning:

BUILDING

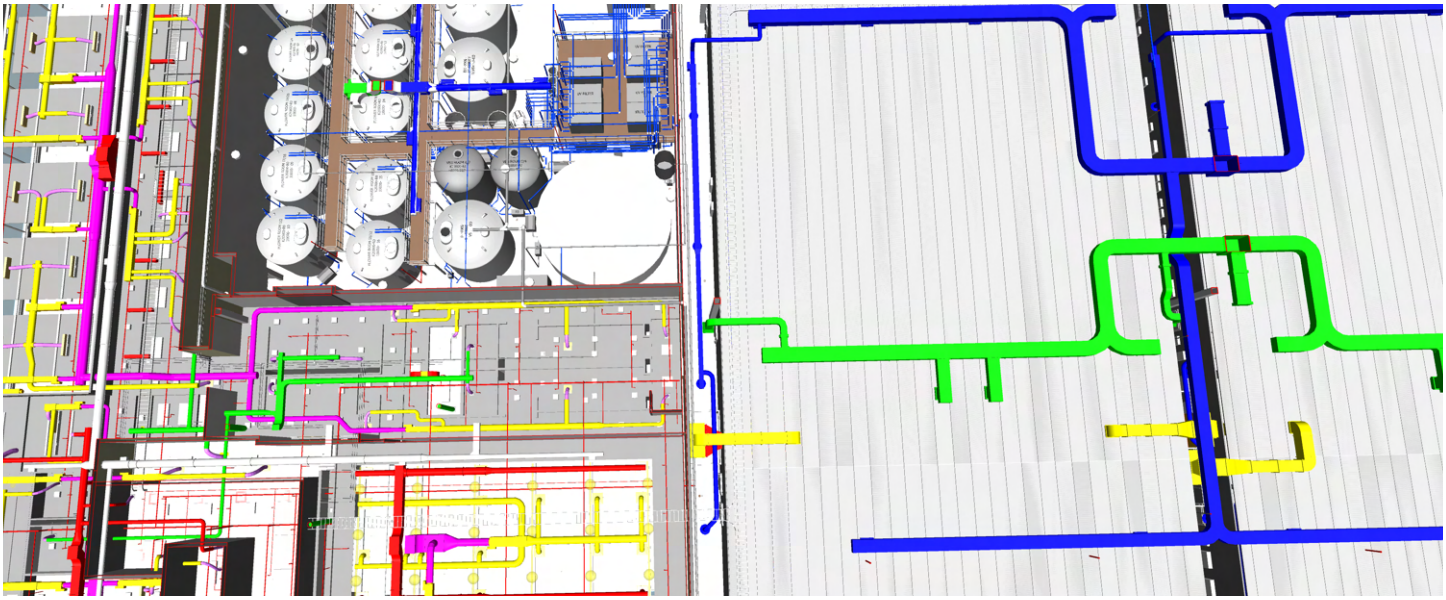
The 'Building' part of BIM refers to the structure or project in question. With BIM, we can control and analyze the different life stages of a project, including planning, conceptual design, project construction processes, facility operations, alterations and finally, deconstruction.

INFORMATION

In the context of BIM, we understand 'Information' to mean all information or data generated throughout the life cycle of the asset(s). This can include construction drawings, construction details, technical specifications, system (structural, mechanical, electrical, etc.) calculations, facilities' calculations, energy models, measurements, budgets, planning work, documentation and maintenance.

MODELLING

The 'Model' part of BIM refers to the various components or functions that make a project work. These include planning, surveying, architecture, structure, facilities, economic viability, etc. Creating a geometric model or digital drawing as part of this process allows buildings to be conceived collaboratively and tested virtually before they are built and operated for real.



2 CHAPTER 2 WHO USES BIM?

WHO IS USING BIM, AND WHAT ARE THE BENEFITS?

BIM is capable of improving nearly any aspect of a construction project, from scheduling to communication to materials ordering. It serves as a single source of truth for all stakeholders, keeping everyone on the same page throughout the project. The siloed nature of many construction projects means various trades involved don't always know what others are doing, which could result in teams working at cross purposes. BIM eliminates those silos, bringing all project data together under a unified, always up-to-date view.

By ensuring smooth coordination between trades, schedules are optimized, and projects can be more consistently completed ahead of schedule and under budget, boosting companies' bottom lines and helping secure their reputation for delivering high-quality work more accurately and efficiently than competitors, helping them win more work.

BIM's communication systems also improve jobsite safety, allowing architects to predict potential safety hazards and modify the design to eliminate them. Since BIM documents every detail of a project's workflow, general contractors can ensure all safety regulations are being met ahead of site inspections, and that they're able to accurately answer any questions that arise during site walks.

Surprises in construction are the enemy of efficiency and accuracy, and BIM improves project predictability by empowering everyone in the field to confidently proceed with the task at hand with the knowledge the model they're viewing from their mobile device contains only accurate information. Armed with these 3D models, workers in the field can quickly and easily compare the BIM model to what they're seeing on-site, take measurements, report back to supervisors, and easily navigate between a 2D drawing and 3D view.

The construction industry is undergoing rapid changes, pushed along by widespread digitization and the introduction of technologies like BIM that help contractors deliver projects more efficiently, improve team coordination, and design better buildings.

BENEFITS FOR GENERAL CONTRACTORS INCLUDE:

- Coordination with the project team, trades, and stakeholders
- The clarity in design concepts and intent
- Increased trade efficiency and allocation
- 'Live' QTO projections (3D Quantity Take-Offs)
- Higher submission quality (QC)
- Faster coordination processes for the production (Pre-Fabrication)
- Removal of silos
- 4D Simulations (3D Model + Time)
- 5D Simulations (3D Model + Time + Money)
- KPI/Dashboards for ongoing project information
- Increased understanding of site logistics

2 CHAPTER 2 WHO USES BIM?

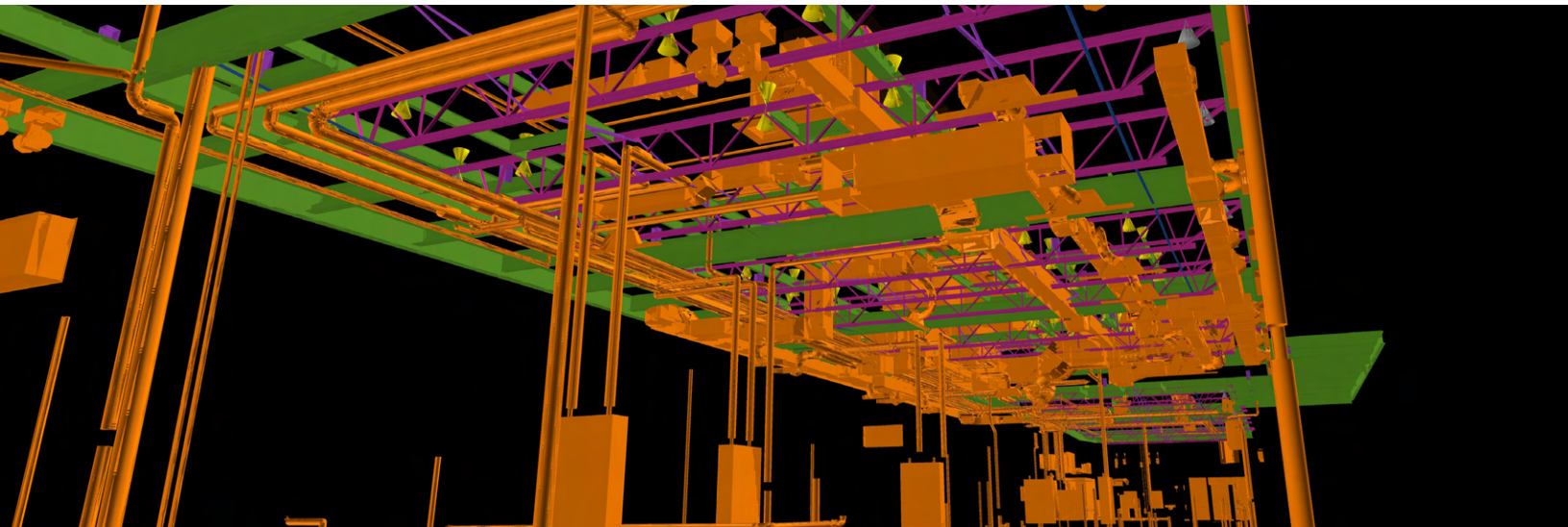
AS A GENERAL CONTRACTOR, WHY SHOULD I KNOW ABOUT BIM?

The rationale behind why BIM may be beneficial to a general contractor (GC) varies on the project delivery method. BIM helps contractors eliminate problems in virtual space before construction gets underway in the real world, reducing the need for costly rework and ensuring projects remain on schedule. Since much of the "magic" of BIM occurs in the cloud, project teams can collaborate in entirely new ways, working at peak efficiency without worrying about incorrect or outdated information as a project's parameters change.

Generally speaking, money is largely spent and saved during the construction process. Despite this, money spent in up-front design yields better results and cost savings during the construction phase. On average, a dollar spent on proper design is equivalent to $100 at the construction phase. BIM can also help general contractors reduce rework and keep budgets in line. The benefits listed above allow general contractors to gain higher value on a project because savings can be passed on.

WHY GENERAL CONTRACTORS SHOULD CONSIDER THE IMPLEMENTATION OF BIM:

- Cost savings on identifying efficiency (prefabrication/pre-building/saving time on schedule)
- 'Supercharge' your other departments (estimating, business development, operations)
- Reduced time in coordination, clear communication (reduced cost per RFI)
- Minimize required change orders to the owner
- Meeting the demands of clients to deliver a digital asset
- It just looks cool

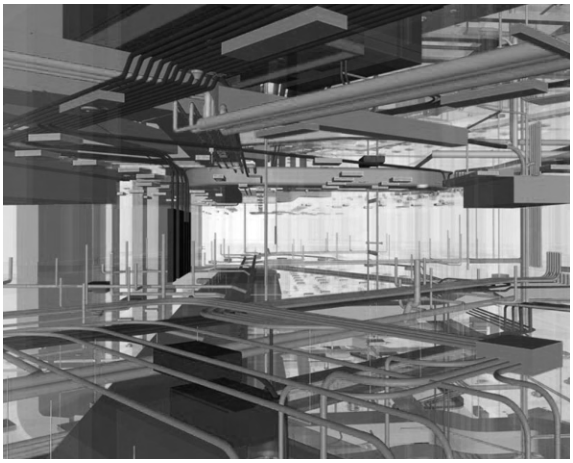


2 CHAPTER 2 ADVANTAGES

WHAT ARE THE ADVANTAGES OF BIM FOR CONSTRUCTION MANAGEMENT?

The main advantage of BIM for construction management (CM) is through integrated project delivery (IPD). This has been proven to be effective in project management. It facilitates the exchange and movement of data resulting in improved productivity, faster delivery times, cheaper costs, minimal litigation, and a more enjoyable experience.

- Improved collaboration and better control among project stakeholders
- Increased staff and trade productivity
- Higher quality projects
- Faster project delivery
- Minimize Risk / Increase Reward
- Cost-effectiveness
- Reduced waste
- Better revenue
- New business opportunities



WHAT ARE THE ADVANTAGES OF BIM FOR ALTERNATIVE PROJECT DELIVERY METHODS (DB, P3, IPD)?

Alternate Project Delivery methods, such as design-build, integrated project delivery (IPD) and public-private partnerships (P3) are increasingly gaining focus in construction markets compared to traditional design-bid-build approaches. From concept to construction, all these processes are defined by early engagement by all key stakeholders.

Many of these methods put an increased focus on collaborative forms of project delivery. IPD especially, is a project delivery method distinguished by early collaboration between cross-functional teams through all phases of design, fabrication, and construction.

By entering this type of contractual agreement, teams can collaboratively harness the talents and insights of all participants to optimize project results, increase value to the owner, reduce waste, and maximize efficiency through all phases of design, fabrication, and construction. By entering into an IPD-based contract, all shareholders share both the risk and reward of the final project costs. This incentive initiates coordination that you would typically not see on Lump Sum / Guaranteed Maximum Price contract-based projects.

The hallmarks of an IPD project are shared objectives, the consensus in decision making, and the use of BIM to provide seamless collaboration between the design team, owners, general contractors and subtrades.

2 CHAPTER 2 BIM LEVELS

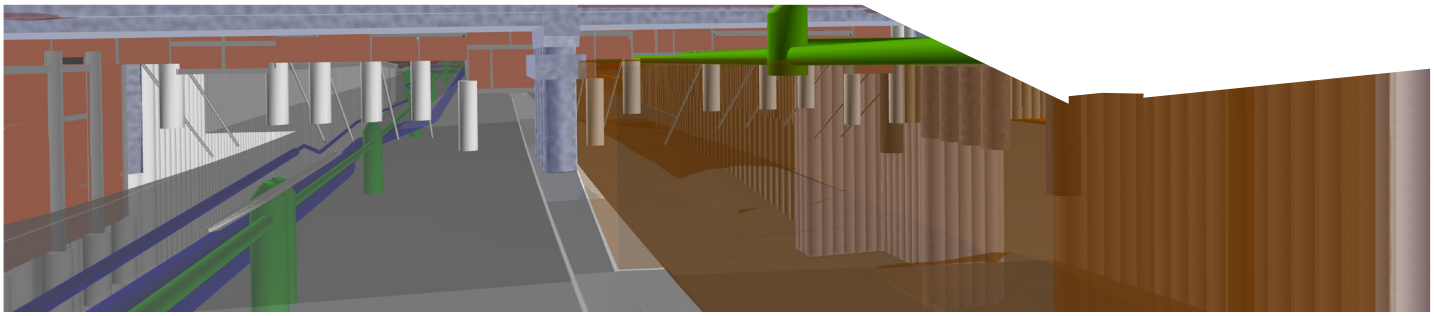
WHAT ARE BIM LEVELS?

There are many 'levels of maturity' of BIM. Even on a single project, you may have consultants who have the capabilities to reach different levels. Although there are overlapping procedures and processes amongst the different BIM levels, we have explained them below:

LEVEL 0 BIM	Level 0 BIM refers to not operating collaboratively at all. If you're using 2D CAD and working with drawings and/or digital prints, you can safely say you're at level 0. Today, most of the industry is working above this level.
LEVEL 1 BIM	Using 3D CAD for concept work, but 2D for drafting production information and other documentation, probably means you are working Level 1 BIM. At this level, CAD standards are managed to the standard of BS 1192:2007, and the contractor usually manages the electronic sharing of data carried out from a common data environment (CDE). Many firms are at Level 1 Transitioning to BIM.
LEVEL 2 BIM	BIM level 2 promotes collaborative working by giving each stakeholder a federated BIM model. Collaborative working is the distinguishing aspect of this level, it requires streamlined information exchange related to a project and seamless coordination between all parties and the stakeholders. Individual parties work on their local BIM models and infromation is exchanged through a common file format. This process allows organizations to combine external data with their own model to create distinct a BIM Model.
LEVEL 3 BIM	BIM level 3 is an ever-changing goal. As technology continues to develop, the threshold and capabilities of BIM continue to expand exponentially. The concept is that all 3D models and project relevant data are stored, shared, and manipulated in a real-time collaborative environment. At BIM level 3, you start to see additional project parameters introduced into the process. Some examples are construction sequencing, costing, asset lifecycle management.

Although reaching the highest standards in BIM is a common goal in the construction industry, it is not the endgame.

By achieving the processes and procedures that are associated with BIM level 3, this will allow the continued integration of IoT and further development into AI and Machine Learning of construction.



2 CHAPTER 2 BIM LEVELS

ARE THERE STANDARDS OR GOVERNMENT REQUIREMENTS FOR BIM?

Global BIM standards have been published by the International Organization for Standardization (ISO). These new standards include:

PART 1	PART 2	PART 3	PART 4	PART 5
Concepts and Principles	Delivery phase of the assets	Operation phase of the assets	Information Exchange	Security approach to information management

These are the current ISO 19650 standards, and they refer to the digitization and organization of data about civil engineering works and buildings, including BIM. ISO 19650 is based on two British standards:

- **BS 1192**
- **PUBLIC STANDARD PAS 1192**

According to ISO, these global standards aim to provide a more effective framework to help contractors and designers by making their collaboration more efficient, improving all phases of construction. Part 3 is on its way, and it will be focused on managing the operational phase of assets, while Part 5 will deal with asset management, digital built environments, and BIM security. For more information on BIM standards in Ontario, please contact the OGCA.

WHAT TECHNOLOGY DO I NEED?

Investments in technology should always maximize the longevity of the investment. Like any business decision, those looking to invest in BIM software should start slow and seek expert's advice. There are many different BIM technology solutions for general contractors, and each depends on the user's workflow and needs.

WHAT ARE THE HARDWARE REQUIREMENTS? WHAT SOFTWARE INFRASTRUCTURE DO YOU NEED TO EXECUTE BIM AS A GENERAL CONTRACTOR?

Modern trends in BIM modelling software involve taking into consideration certain aspects, such as time and costs. It should be based on the software and production requirements. You may need to consider how you want to run this (integration, silos, or distribution).

HARDWARE AND IT INFRASTRUCTURE CONSIDERATIONS SHOULD INCLUDE:

- Data storage (VDC files are typically huge)
- Workflow needs and collaboration requirements
- Cloud-based platforms
- Computer Processing power

SOME CURRENT BIM SOFTWARE SOLUTIONS INCLUDE:

- Revit
- Revitzo
- Navisworks
- Archicad
- AutodeskBIM360

BIM viewers, more widely knowns as IFC viewers, allow you to upload an IFC file and read its properties. Some of them let you only navigate the IFC model, whereas some others allow you to edit it, convert it to other formats, add properties or view more files at the same time. Some popular BIM viewers that can be used to access a BIM file include:

- Procore BIM Viewer
- BIM Vision
- Solibri Anywhere (Solibri Model Viewer)
- Areddo
- Autodesk Viewer

For many experts, BIM's power is more about collaboration and process, than the software itself. Many software solutions will accomplish the task, but it is more of the process that needs to be implemented and sustained.

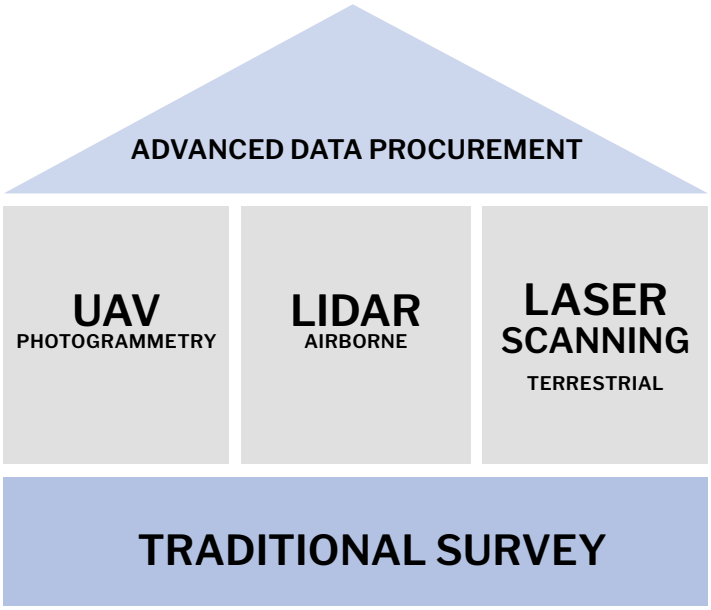
For general contractors looking to invest in BIM, more emphasis should be made towards adopting a common data environment and process.

3 CHAPTER 3 REALITY CAPTURE

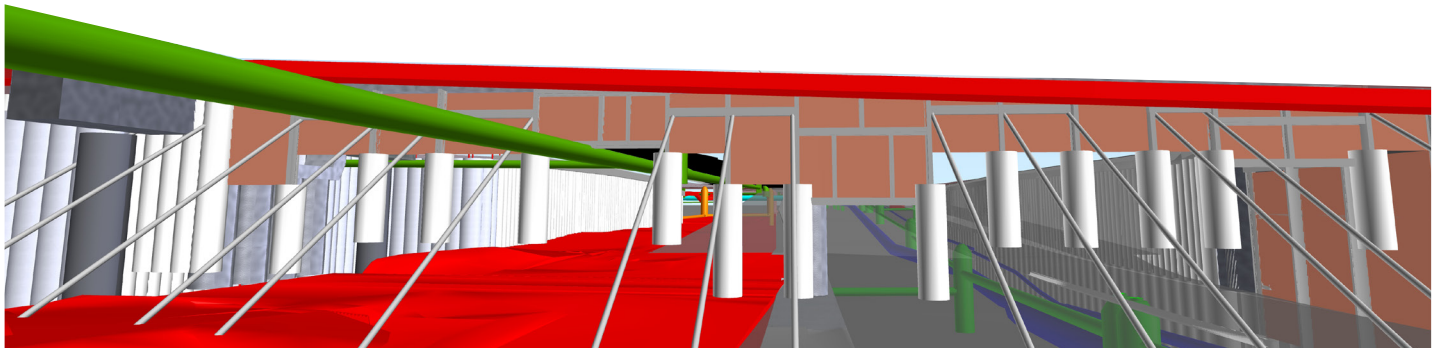
WHAT IN THE DIGITAL WORLD IS REALITY CAPTURE?

Reality capture can be a simple, quick and cost-effective means of gathering accurate data about real-world conditions through various forms of scanning. This process captures detailed "as-built" information that can be used to determine detailed information of a built infrastructure project.

CAPTURE	COMPUTE	CREATE/CONSTRUCT
Using laser scanning and/or photogrammetry to scan a site and collect detailed data. This data may contain both measurements and photographs.	Using software, scanned data is stitched into a coordinated grid system where it is analyzed to produce a "point cloud" ready for data extraction using various BIM Software.	The "point cloud" is then used as a reference for various tasks, from generating 'as-founds' for designing to construction validation.



After the capture step, the data-processing workflows for laser scanning and photogrammetry are very similar. They involve aligning or registering the data in a coordinate system or project model. This is truly where the "magic" happens. A Point cloud is a set of data points in some coordinate system, containing X, Y, and Z coordinates and can also contain RGB values (a Red, Blue, Green colour code) for each individual point. These data sets can range in size from a few hundred megabytes to monster files containing 100s of gigabytes of data.



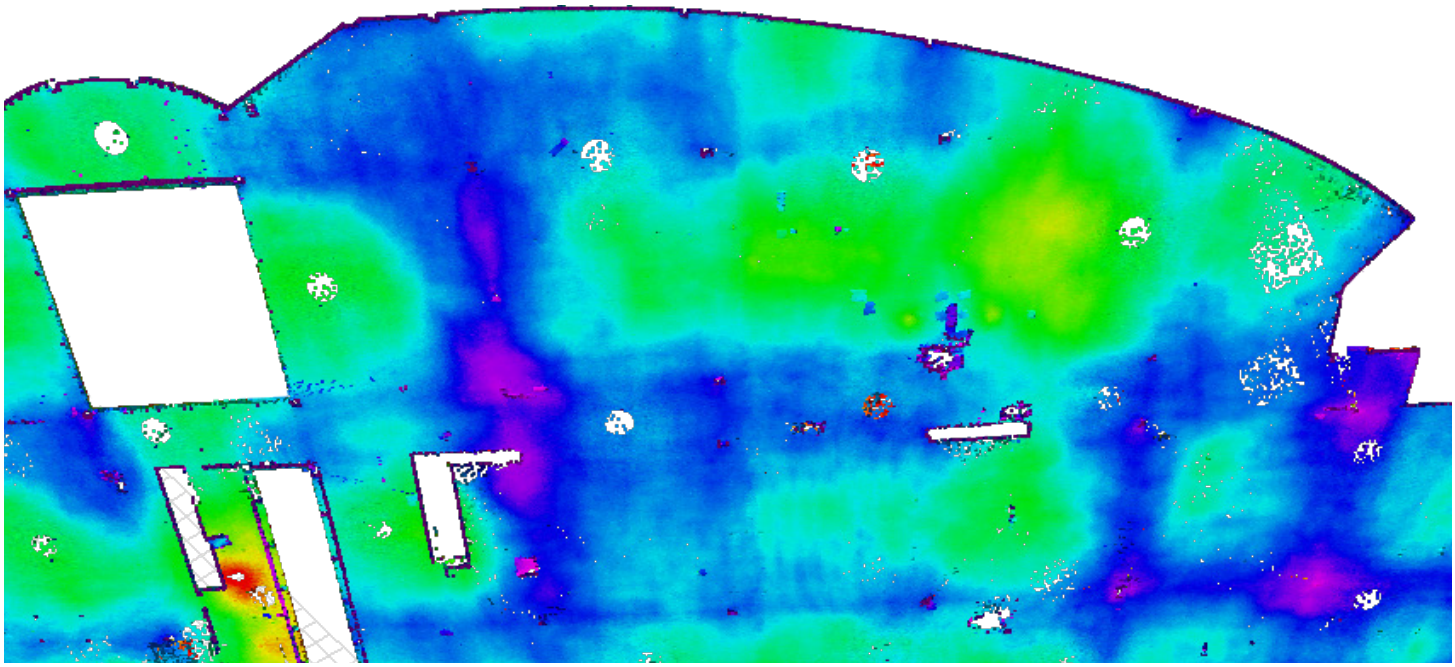
3 CHAPTER 3 POINT CLOUD

DO I NEED A POINT CLOUD?

A Point Cloud is a digital file that contains a lot of information about existing conditions. Although this is extremely valuable to any project, there should be an understanding that all this information may not be in a format that suits your needs. For example, using cloud-based/local software, you could take some dimensions yourself. You would still need someone with construction drafting skills to generate as-found construction drawings by utilizing the Point Cloud and BIM Software.

Another example would be doing a digital 'walkthrough' with the right software to view the scan but would have to export the images if you wanted a series of photos. These processes can be time-consuming.

To answer the question, 'Do I need a point cloud?', yes, you do but ensure you have someone available with the skillsets required to analyze, extract and convert the data into a format that is suitable to your needs.



3 CHAPTER 3 APPLICATIONS

WHAT ARE THE PRACTICAL APPLICATIONS FOR REALITY CAPTURE?

Data sets of the site can be captured before, during, and on completion of projects to improve visibility and control at all construction stages. At all stages of the project, the model can identify any discrepancies, assist in making key decisions, and communicate complications before they become costly, mitigating implications to your construction budget and schedule.

AS-BUILT MODELLING (SCAN TO CAD/ BIM)

The data obtained in reality capture can be fed directly into the BIM model to ensure that what has been built conforms to design plans, verifying the accuracy and validity of the on-going construction process.

SITE AWARENESS AND VISUALIZATION

Throughout the project life cycle, the point cloud is shared with all stakeholders. Progress can be documented and digitally signed-off per the design. This means progress can be checked off-site from a remote or different location on site. Having the ability to complete digital site reviews and walkthroughs reduces the time and cost of mobilizing on site.

CLASH DETECTION (INTERFERENCES)

A common source of delays for general contractors in new-builds, and more so in renovation projects, arises from components not fitting into their intended locations. This can be through errors in the process or oversights in design. Inside construction software, point cloud data can be used to compare against digital design models, automatically indicating potential conflicts. Issues are then resolved well before any costly impacts.

DEVIATION REPORTING

Meeting specifications and constructing to design is made much more efficient by validating and checking the positional accuracy of work as it happens. This allows contractors to either make corrections or inform others that changes may be required to address any unwanted deviations. Calculated decisions can then be made to avoid costly changes. By way of examples, point cloud data can be used to validate a concrete slab's flatness by generating a tolerance report. Additionally, it could also be used to verify that your structural columns are plumb.

CONSTRUCTION VERIFICATION

During the construction lifecycle, installation errors and rework cost time and money. Utilizing reality capture technologies to record actual site conditions, these snapshots in time can be compared and contrasted against the design model. Any irregularities can be spotted, assessed and corrected before rework is needed. This can also be advantageous post-construction, as reality capture has been known to prevent and defend against any litigation that may arise out of a legal dispute. As such, reality capture data can be considered as a means to effectively demonstrate due diligence.

3 CHAPTER 3 REASONS TO USE

WHO IS USING REALITY CAPTURE?

Reality capture gives you the most accurate and timely data available, helping you make key decisions upon fact and not theory. Currently, reality capture is significantly used by designers and consultants. Contractors are starting to see the significance of tracking the history of a project by generating snapshots in time through scanning regularly. It would be recommended that owners identify stakeholders that are committed to this process. A significant benefit of introducing Reality Capture into your design and construction process is that it allows for better collaboration through the project life cycle. This results in increased productivity, a reduction in scheduling conflicts and an overall better outcome of your project.

Reality capture is currently being adopted across the construction and design community to great effect.

AS A GENERAL CONTRACTOR, WHY SHOULD I KNOW ABOUT REALITY CAPTURE?

Reality capture empowers construction and engineering professionals to manage projects more efficiently by being better prepared to respond to problems at the early stages of the project, avoiding delays and completing the project on time, on budget, and on specification.

TOP REASONS TO USE REALITY CAPTURE AS A GENERAL CONTRACTOR
Projects start with an accurate record, allowing problems to be identified early
Rework and delays can be avoided through collaboration using real-world data, rather than just design
Installation of key elements of a project can be tracked, saving time and reducing site visits
Improved record-keeping
Opportunities to limit claim discussions and capture as-built conditions
General contractors can hold subtrades accountable as all parties can see real-time progress

3 CHAPTER 3 TECHNOLOGY

WHAT TECHNOLOGY DO I NEED?

To better understand the technology required, one should understand the difference between laser scanning and photogrammetry.

PHOTOGRAMMETRY

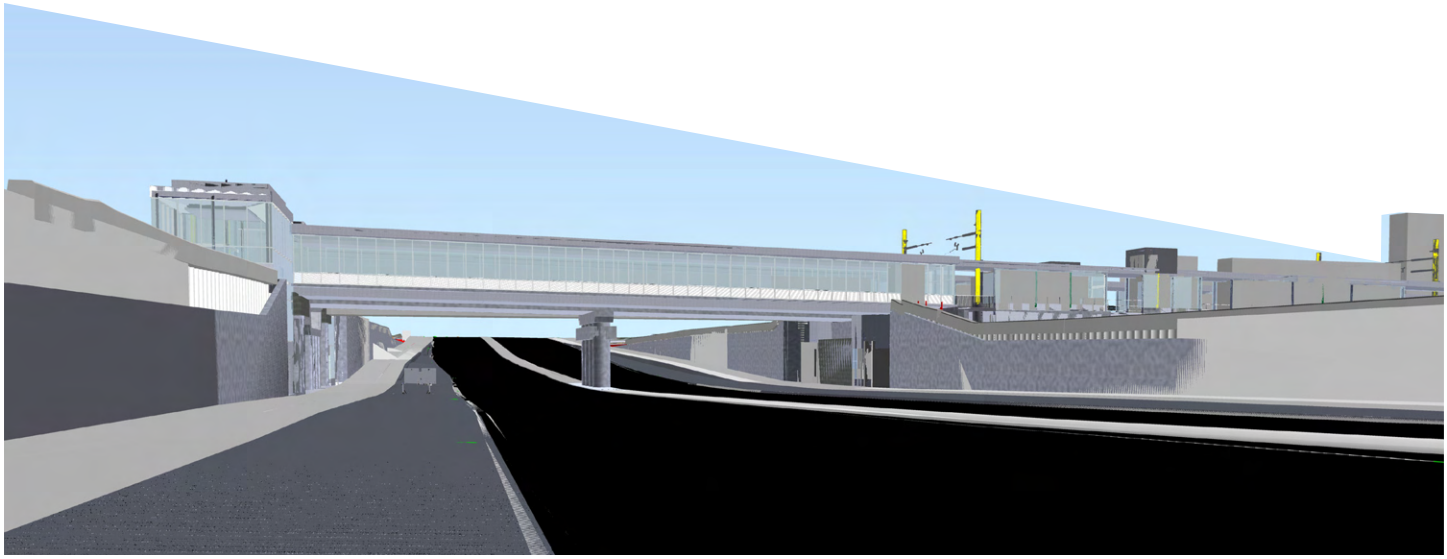
There are several different approaches to photogrammetry. This can be as easy as a cellphone camera to capture the information, or as complex as a drone-mounted scanner operated by a certified drone pilot. Unmanned arial vehicles (UAV) cover large areas or places that would be otherwise hazardous to visit. Both solutions excel in providing still and video imagery or live video for situation analysis. You would typically find this utilized for civil/topography related tasks such as cut/fill calculations or site logistic planning.

LASER SCANNERS

Lasers provide highly accurate data with very tight tolerances. They are typically used for confined spaces or for jobs that have higher accuracy. This is often geared more towards building component-related tasks.

Software and hardware are essential components of reality capture.

Software and hardware are essential components of reality capture. The technology solution a general contractor needs is based on whether they will be completing the scanning and post-processes themselves or just accessing compromised data for project specific required information. The options continue to develop rapidly as construction technology moves forward from a USB stick and free point cloud viewers to subscription cloud-based online platforms to host collected information.



4 CHAPTER 4 GIS

WHAT IN THE WORLD IS GIS? (GEOGRAPHIC INFORMATION SYSTEM)

A geographical information system is a framework to organize, communicate and understand the world around us digitally. Derived from geography and project-specific data, GIS integrates many types of data, to create a "layer cake" of maps, visualizations and 3D content. This unique data visualization method allows users to get deeper insights into data - such as patterns, relationships and situations - to get more in-depth analysis, providing an opportunity to reduce risk on a project.

HOW DOES GIS WORK?

GIS works by taking a wide variety of site-related information and compiling it to make it easier to interpret, analyze and distribute. You can use the data to help explain, plan or produce a result which can help solve a problem, answer a question or complete a task.

GIS experts use the technology on four different "levels":

MAPS	Maps are the geographic container or "pan" for the "layers" of data and analytics.
DATA	GIS can integrate the many different kinds of data layers using this spatial location. Most data has a geographical component. Examples include satellite photography, population density, soil conditions and servicing lines (hydro, gas, etc.). Data can include images or base maps linked to spreadsheets and tables.
ANALYSIS	Spatial analysis lets you evaluate suitability and capability, estimate and predict, interpret and understand, and much more. New perspectives also allow users to gain new insights, analyze data visually and improve decision-making.
APPLICATIONS	GIS data can also be accessed, interpreted and used through applications that allow users to access data anywhere.

4 CHAPTER 4 INTEGRATION

HOW DOES GIS INTEGRATE WITH BIM AND REALITY CAPTURE?

Integration between GIS, BIM and reality capture is best illustrated through the lens of a large scale IPD (integrated project delivery) project. An undertaking of this size and investment requires architects, engineers and constructors to access information about the built and natural environment throughout the construction process.

Accurately setting out a new project traditionally involved identifying a fixed point of reference (a temporary benchmark), a baseline, and then a network of horizontal and vertical control points, accomplished by using measuring chains, theodolites and other surveying equipment. This process can be inefficient and is very susceptible to user error.

However, contemporary theodolites have increasingly been replaced by total stations. They combine theodolite functions with electronic distance meters, meaning they can accurately capture and process data for further use by computer-aided design (CAD), building information modelling (BIM), or GIS software. For more information on this, see our information on BIM and reality capture.

WHY WOULD A GENERAL CONTRACTOR NEED GIS?

General contractors use GIS to synthesize and interpret data collected on the job site to frame decision-making in context. Provincial and Municipal Governments, school boards, public health units and other purchasers of public infrastructure are increasingly turning to GIS technology to make data-based decisions about where to locate public infrastructure. By using demographic, traffic and geographical statistics, they are able to use data-based decisions when locating schools, transit infrastructure, first response stations and traffic mediation infrastructure to better serve their respective jurisdictions.

Some practical examples for General Contractors include:

- Project mapping
- Staying updated on construction status using volume, stockpiles
- Finding the location of existing infrastructure like water mains, sewer mains and network supports for new developments
- Collecting and analyzing air/soil quality data
- Tracking where contractors are working and planning future logistics
- Location verification of walls, vents and ducts to meet as-built conditions

4 CHAPTER 4 INVESTING

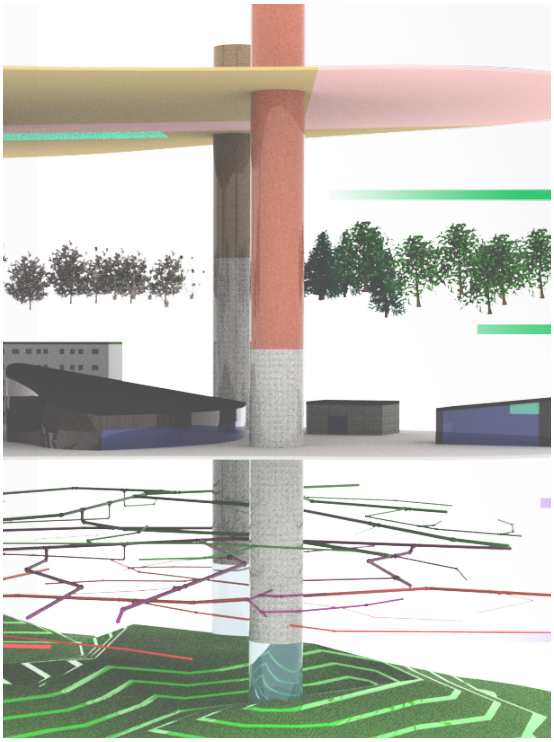
IS IT WORTH INVESTING IN GIS?

For decades, GIS has been used by city planners and government officials to locate public amenities and plan critical infrastructure.

In some jurisdictions, permitting and project approval must, by law, be presented in GIS format. This allows for permits to be issued in an efficient, compatible and usable manner for approval.

As GIS is used so heavily in the permitting and planning stages of ICI projects, many general contractors have been roughly working in the GIS industry already. As technology becomes universal, GIS has already been shown to improve workflows, promote collaboration, and build strategic partnerships among construction stakeholders.

GIS has been incredibly beneficial in the development of "smart communities" and assets for the future. By adding location to design, stakeholders can understand projects in context and deliver repeatable solutions.



HOW SHOULD A GENERAL CONTRACTOR START INVESTING IN GIS?

As the return on investment for GIS is based on integration with other construction technology, the best starting point for a general contractor would be to talk to a consultant to understand your needs.

Those interested in accessing pre-made GIS data can also use free and powerful tools like QGIS, a free and open-source GIS system. Most municipalities have a free to use GIS platform that consists of development & planning related information, such as zoning maps and property boundaries.

Training is a critical element of any investment in construction technology and will help general contractors understand how to interpret multiple sources of data efficiently. It will also expose more benefits of GIS specific to the project and the users' needs.

5 CHAPTER 5 BUILDING A BIM TEAM

WHAT ARE THE SPECIFIC ROLES YOU NEED IN A BIM TEAM?

When polled, project managers and general contractors frequently emphasized that putting a team together is something they took very seriously. Projects that practice BIM processes tend to rely on an extreme degree of precision. BIM is an "on-going" process, not a "one-time" deliverable. Although implemented to various degrees on each site, successful projects that use BIM or VDC require people at all levels, from architects to field managers, to have a fundamental understanding of what BIM is and how it is interdependent on every aspect and contributor.

This understanding is important as the BIM process is what brings all components of a project(s) together. By prioritizing its integrity and accuracy, all project stakeholders can refer to the outputs of this process (such as a collaborative BIM Model, or a common data environment) to confidently obtain and analyze information relevant to the individual or party. The impact can go far beyond just clash detection. General contractors who engage with the BIM process can also benefit from the expertise of all project stakeholders, from owners to facility management. It's important to maintain your BIM process and to not deviate from the plan and 'Go back to CAD' at any part of the project life cycle. Reverting back to a non-collaborative approach will ultimately cost you time and money.

Each role presented will provide a description, followed by a list of preferred attributes.

ARCHITECT/PRIME CONSULTANT

Architects and/or the prime consultant must be 100% dedicated to the BIM process. Their responsibility to organize and coordinate the other consultants, puts them in a position best suited to manage multiple BIM models. Ensuring other consultants and parties continue to follow a BIM execution plan is an important aspect of this role.

Particularly for Architects, BIM is a process that, when implemented, develops an integrated system for design development and planning. In this way, BIM is truly a way of ensuring the design meets the project requirements and facilitates collaboration with other teams and construction stakeholders.

PREFERRED ATTRIBUTES:

- Provides project management experience
- BIM Authoring Software usage necessary
- Ability to lead and enforce BIM Requirements with Consultant Team and other stakeholders
- Supports and supplies missing design scope that may not be covered by the current team of stakeholders
- Understanding of the importance of data within the BIM Model / Common Data Environment
- Can provide, manage, or understand the requirements of a BIM Execution plan
- Hosts/participates in BIM Coordination Meetings regularly to facilitate transparent inter-team communication

5 CHAPTER 5 ROLE DESCRIPTION

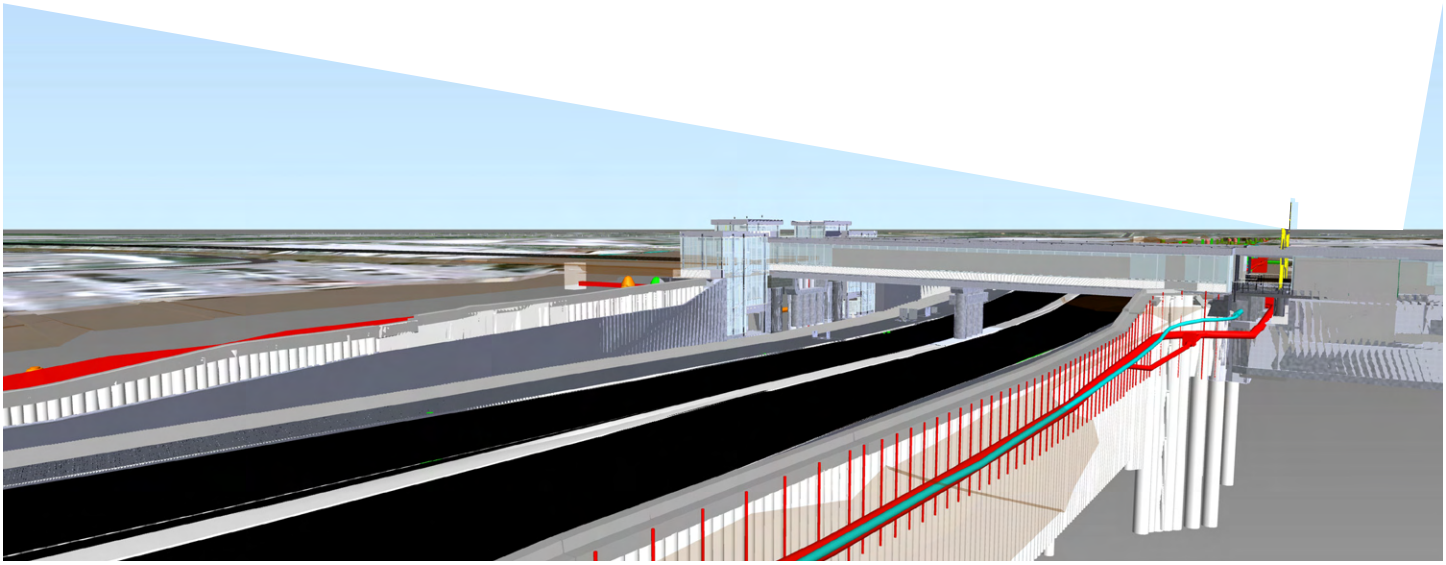
ENGINEERS/DESIGN CONSULTANTS

Engineers typically take the duties of a BIM Manager and are responsible for implementing the BIM execution plan as designed by the architect or general contractor. They create the digital construction procedures at the design stage, monitor construction throughout the project life cycle, and hand over the responsibility at various project stages.

A BIM Manager's role and responsibilities may vary depending on whether the individual is working for the client, contractor or designer. Most roles integrate both the digital construction planning and information management as it relates to the as-built conditions. Engineers, or BIM consultants, also manage any changes needed to the BIM model. A BIM Manager may work with Quantity Surveyors, Designers, Planners, and other Engineers to assist in manipulating and extracting information from data-rich models on a day-to-day basis.

PREFERRED ATTRIBUTES:

- The creation of Employers' Information Requirements (EIRs). The EIR document explains the client's preferred systems, processes and required outputs from their supply chain
- The creation of BIM Execution Plans (BEPs) A BEP is created in response to an EIR and explains how the project team intends to meet the client's information requirements
- The monitoring of supply chain performance and, where necessary, implementing appropriate training and upskilling to ensure information delivery
- The capture and integration of asset data within the BIM environment, including linked data
- The setup and maintenance of the Common Data Environment, including the alignment of workflows with the project BIM protocols



5 CHAPTER 5 ROLE DESCRIPTION

CONTRACTOR/CONSTRUCTION MANAGER

BIM helps contractors eliminate problems in virtual space before construction gets underway in the real world, reducing the need for costly rework and ensuring projects remain on schedule. Since much of the "magic" of BIM occurs in the cloud, project teams can collaborate in entirely new ways, working at peak efficiency without worrying about incorrect or outdated information as a project's parameters change.

Contractors can use building information models to coordinate building systems, detect clashes (interferences), and immediately communicate these problems with the parties responsible for the errors. Other tasks such as quantity take-offs, schedule verification and digital site visits are resources that should be facilitated as well.

Mobile-friendly BIM solutions such as BIM360 FIELD and A360, makes revit and other design files available at a general contractor's fingertips while on-site. This allows the project team to view and quickly check how the as-built conditions reflect the modelling. Having access to the BIM file can also help communicate with all parties, such as specialized subcontractors, owners, the design team and eventually building management when the project is completed.

PREFERRED ATTRIBUTES:

- BIM Management Experience
- Ability to lead and enforce BIM Requirements with Consultant Team
- Ability to manage, translate and view BIM Files
- Willingness to contribute information (schedules, point clouds, productivity)
- Ability to manage and analyze BIM Data/CDE
- Macro and micro 4D (3D models integrated with scheduling) simulations for live projects and tenders to assist project planners
- Modeling quantity take-offs to assist quantity surveyors, estimators and planners
- 3D Site logistics plans
- Detailing 3D concept imagery of Temporary Works ideas to help engineers progress their designs
- Visualizing Method Statements to highlight potential risks and prove the construction sequences and then using it to brief site operatives
- Understanding of point cloud information to assist and confirm construction sequences and the extraction of exact dimensions and quantities

5 CHAPTER 5 ROLE DESCRIPTION

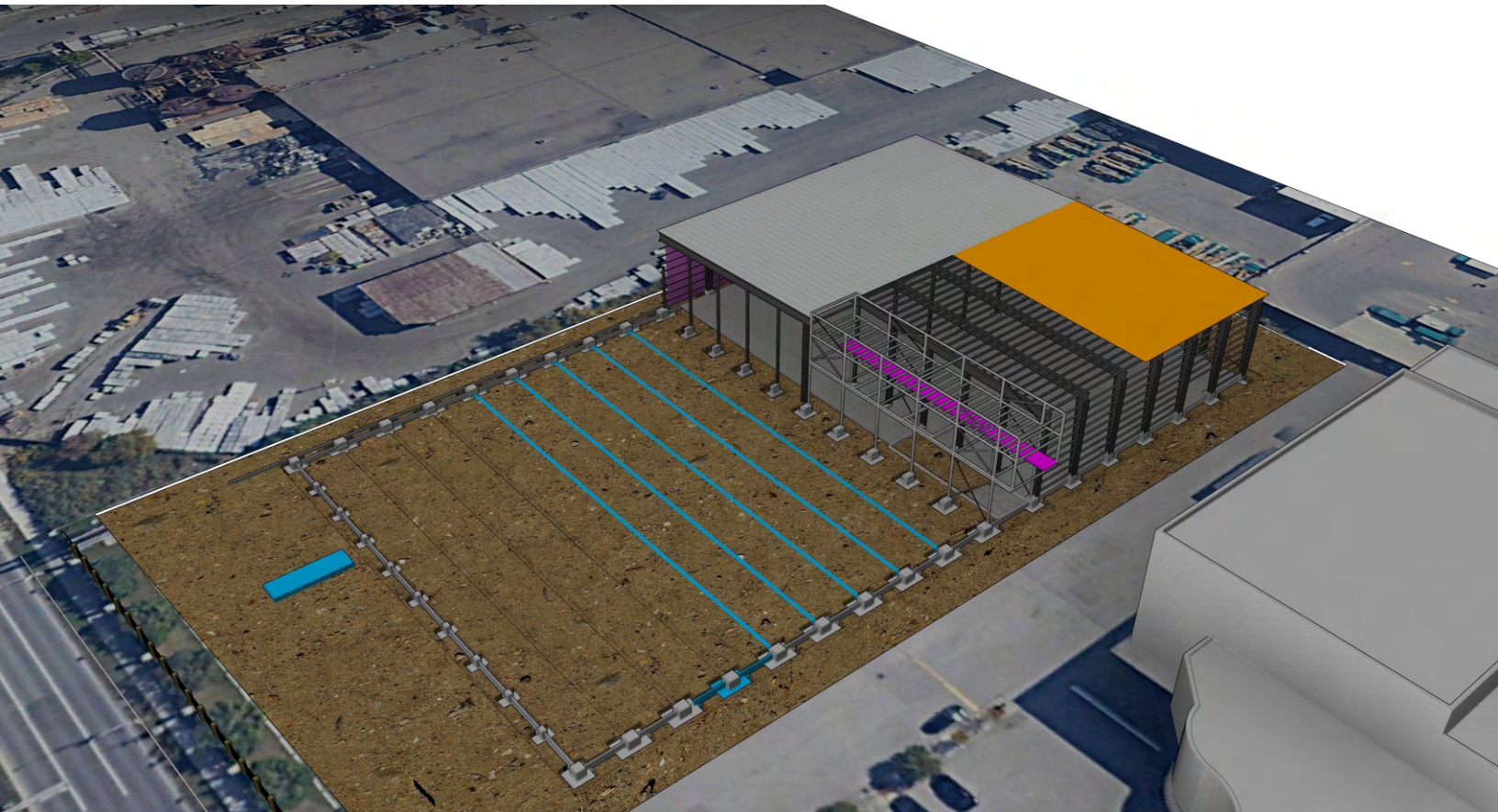
OWNER

Numerous studies have shown that owners with an understanding of BIM have a greater likelihood of increasing their ROI and overall satisfaction with a project.

Increased owner engagement with BIM provides more precise and accurate visualization of the design's intent and purpose. This simplifies the communication with owners because realistic 3D visualization models are easier to comprehend than 2D drawings.

PREFERRED ATTRIBUTES:

- Understanding at a high level, the different tools, and techniques available (Clash Detection, D Simulations, Quantification, etc.)
- Understanding who can interpret the specific BIM process (A Point Cloud hosts a great deal of data, but you would need someone with the capabilities to take measurements, generate reports, or even extract images)
- Communicating desired deliverables from the BIM Process (point cloud scanning at specific intervals, model data to be extracted in a specific format for facility management, frequency of updated 4D schedules, format of collaborative model)



5 CHAPTER 5 ROLE DESCRIPTION

TRADES/SUBCONTRACTORS

Subcontractors using BIM see significant improvements to the overall efficiency and productivity, and become connected to the design, engineering, manufacturing and procurement processes. This is essential in prefabricated processes where coordination is critical to meet increasingly complex construction environments' needs. The most common subtrades involved in the BIM modelling include: mechanical (HVAC); pipefitters; electricians; roofers; window glaziers; and subcontractors involved in prefabrication. The success of BIM for any project depends largely on the subcontractor's level of understanding.

When subcontractors become a part of the BIM team and are responsible for providing specific data, feedback, and deliverables based on the model, subcontractors learn how work gets utilized in the larger scheme of things. This is hugely beneficial for general contractors as well as all stakeholders.

PREFERRED ATTRIBUTES:

- Participating in BIM Coordination Meetings regularly
- Willingness to contribute information (project progress/schedules)
- Utilizing and navigating the BIM/Collaborative model effectively
- Ability to generate/provide fabrication models where required

SUPPLIERS/VENDORS

BIM not only has an impact on designers, but it also impacts the supplier chain of construction products. As modelling and project requirements become more complex, suppliers must provide digital content for a BIM model.

For example, Hilti Corporation — a leader in providing electronic tools and fastening and protection applications for construction professionals — has developed a seamless integration of their products into a variety of BIM authoring software.

PREFERRED ATTRIBUTES:

- Ability to generate BIM models of products from design to fabrication (3D Shop Drawings)
- Participates in the BIM coordination meetings to verify product design and installation conformity

FACILITY MANAGEMENT

The BIM process can allow facility managers to integrate 3D models & project related data into their current operations more efficiently.
The hand-over process from construction to operations and maintenance has a reputation for being cumbersome, time consuming and typically, a great deal of information is lost in the transition. Having an integrated process improves the quality and quantity of information that gets handed over, allowing the Facility Management team to make informed decisions, information such as space use, floor planning, equipment and asset maintenance, energy consumption, and cost efficiencies. By indicating the information requirements facility management will need at project hand-over, the amount of information lost in the hand-over is greatly reduced.

PREFERRED ATTRIBUTES:

- Understanding the importance of data within the model
- Clearly identifying data, information, and format of which it is required
- Understanding the value of the model and what value they expect from the model itself

5 CHAPTER 5 ATTRIBUTES

WHAT ARE THE MOST CRITICAL ATTRIBUTES NEEDED IN A BIM TEAM?

Although BIM adoption is quite widespread, each stakeholder in the construction process has different requirements and ways they interface with the BIM process. There aren't many guidelines for recruiting, but there are qualities general contractors can look for in a BIM team. This is especially important during the initial adoption of BIM in a project as the technology will be new, and the value may not be fully seen.

These qualities include:

GREAT COMMUNICATORS	As BIM tools are rolled out across a company, the BIM team plays a role in many different departments and functions. For that reason, communication is a huge factor in creating an effective BIM team. You will likely be relying on your BIM team to roll out software and procedures.
SPEAKING THE LANGUAGES	If BIM tools are relatively new to a particular stakeholder, team members often translate requests into the data they need. Team members who can read between the lines and translate those needs into data and back again are necessities.
BELIEVING IN BIM	BIM is a process that has driven change in the industry and can be leveraged from the beginning to the end of any project. But some organizations don't utilize the BIM process as comprehensively as they could, particularly professionals who have been in the industry for a while. It can be invaluable to have "BIM evangelists" on your team who believe in the process and drive adaptation.
THE SUM OF THE PARTS	As BIM straddles all aspects of design and construction, stakeholders have different roles and different information requirements. Successful teams rely on the experience that each stakeholder member has. All parties need to participate in a collaborative approach and cannot work independently.
SHARPEN YOUR TOOLS	Managers should always look for people who have a deep understanding of all the tools available so that when they have a new project with different requirements, they can instantly look it over, pick the right tools, and get to work.

6 CHAPTER 6 THE FUTURE OF BIM

If one thing is certain, it is that the future of BIM is now.

The democratization and standardization of BIM has made it easier to access resources for all participants. This has also led to an accelerated transformation to full digital twin delivery becoming standard.

Today's construction firms are starting to adopt collaborative technology such as real-time, cloud-powered analytics to mine large structured and unstructured data repositories to make sure all stakeholders – architects, consultants, engineers, subcontractors, specialty tradesmen, clients, operators, agents, and suppliers – are on the same page and informed with real-time data. These technologies have the potential to redefine the industry by offering game-changing benefits.

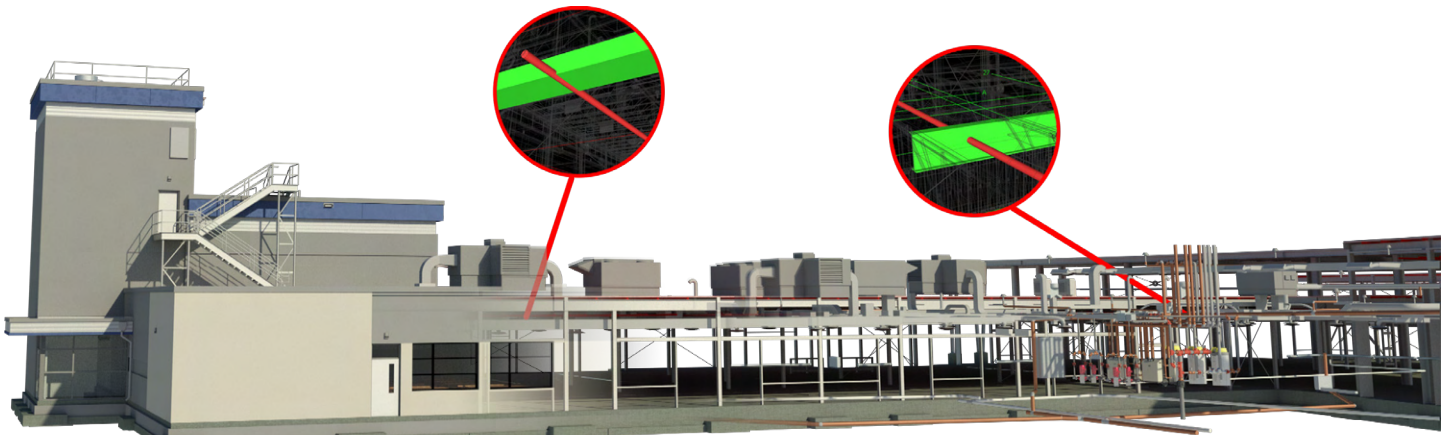
ENHANCED COLLABORATION

As you have seen in this guide, the real benefits of BIM lie in enhanced communication and collaboration across design, construction and management. From this perspective, the future of BIM is about creating connection.

Often referred to as "Connected BIM," it involves leveraging more out of the end-to-end use of models through cloud technology. That means utilizing a connected model-based process, not only in design but throughout preconstruction, in the field during construction, during closeout, and even through operations and maintenance. As BIM evolves, it is like a snowball rolling down a hill that gets larger and larger as it collects more data. It is even gathering dimensions. The three dimensions of the physical world are just the beginning.

There's 4D BIM (which adds in scheduling, or the dimension of time), 5D BIM (which adds in costing information), 6D BIM (sustainability) and 7D BIM (facilities management)—although people disagree about what's included in any given dimension. Others are now talking about 10D BIM and more. The fact of the matter is that BIM should be able to accommodate any and all data about a building.

A blog post on Next's website expands on this idea: "The future of making buildings lies in no longer having distinct design and construction activities—but rather a Master Builder process that seamlessly transitions through design, procurement, assembly and operation using non-linear, fully-iterative and non-traditional approaches, to move any building from design to assembly and beyond at considerably less cost and in less time."

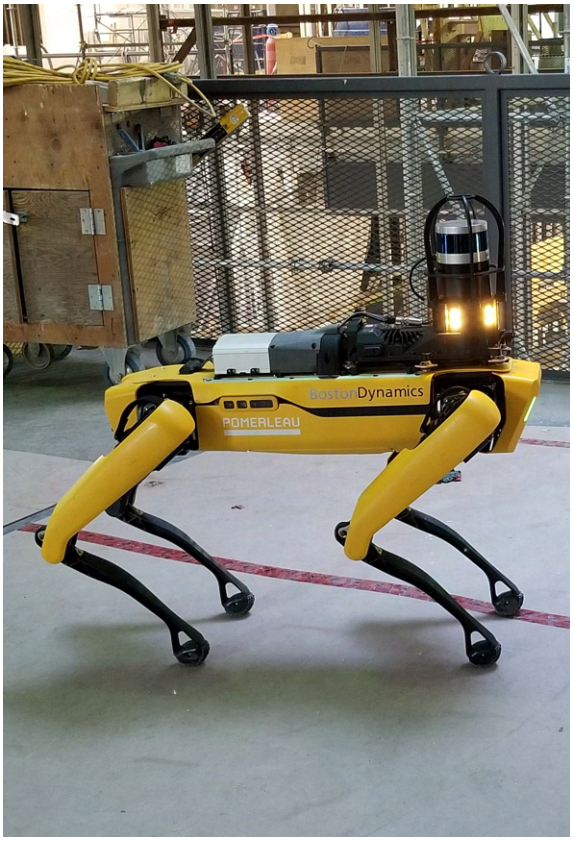


6 CHAPTER 6 THE FUTURE OF BIM

AI/MACHINE LEARNING

While other industries have rapidly transitioned to blockchain, artificial intelligence and machine learning, construction has been slower to adopt due to a lack of "clean data." With so many different stakeholders with different data needs, a universal design platform, such as a BIM model, can harvest data and provide analytics. With accelerated adoption, several firms in Canada have begun data driven projects and are finding new avenues to use software to generate efficiencies, reduce insurance premiums and promote better construction practices.

To better address this challenge associated with generating big pools of data (construction does not organize its data very well), trade and construction associations have begun advocating for data sharing and common data agreements.



DRONES, ROBOTS AND SENSORS

Early adoption of drones, robots and sensors began on large civil projects, as drones could go in dangerous places meaning scans could be done more regularly. The COVID-19 pandemic has led to a rapid expansion of drone and robot usage due to the significant limits on site staff.

Another potential area for development is the increased adoption of robotics in the construction process itself. Robots have already been utilized in most industries, which increased productivity and efficiency.

Why aren't robots utilized in architechture? It could definitely have great benefits on the construction process as robots reduce errors and the rework. Studies in other jurisdictions show that the adoption of robotics nearly doubles the precision of installation, and can build CAD models with meticulous accuracy.

Robots also save time and achieve an efficient timetable, all while managing the construction process and slashing the number of waste materials.

SOME EXAMPLES OF THIS INCLUDE

ROBOTIC SENSORS

Pomerleau equipped Spot with a 360° camera to allow it to capture completed work on the jobsite. Spot's image capture capability is currently linked to the HoloBuilder platform. This integration allows the site manager to compare weekly or even daily images in order to track the site's progress. These images can be compared to the 3D model to visually identify any differences, aiding in the coordination of on-site subcontractors and tradespeople.

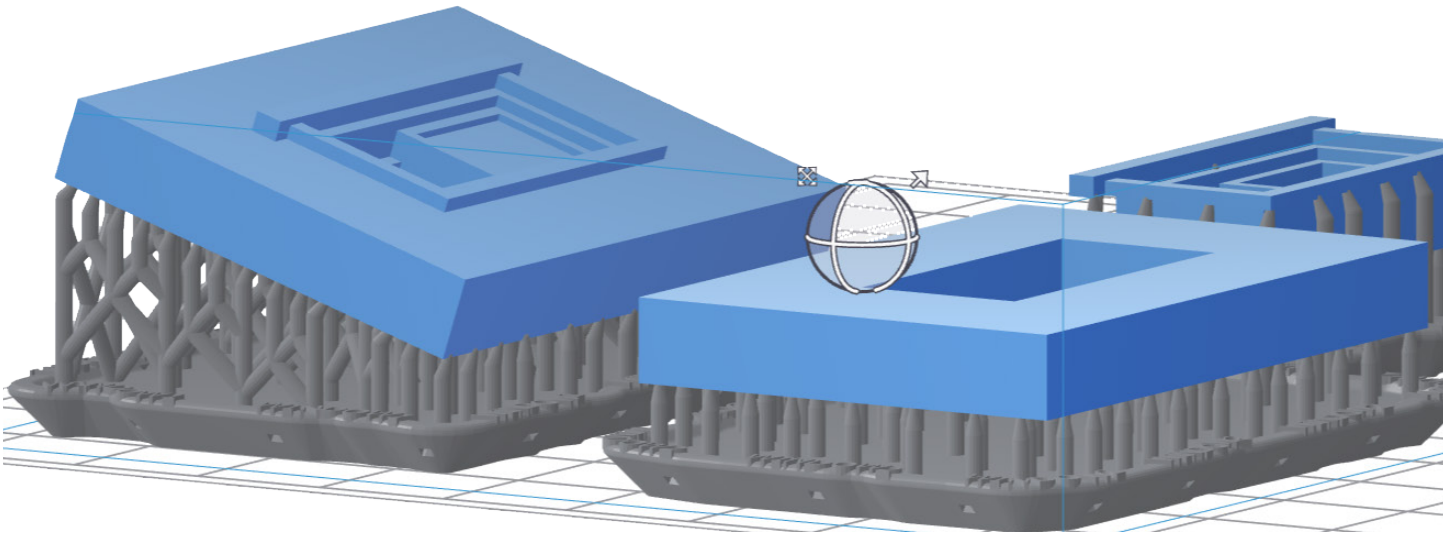
Pomerleau anticipates being able to free-up the typically assigned employee's time by approximately 20 hours per week based on a 500,000 sq.ft. project that requires nearly 5,000 images per week to properly document, allowing that employee to focus on the analysis of the captured data. This deployment has encouraged the team to use HoloBuilder more frequently, as a lot of labor was previously required to collect data to use within its software. After just one month of having Spot on-site to automate dull and repetitive tasks, Pomerleau has already seen a modest reduction in the time required to deliver a project based on their ability to move their workforce towards high-value tasks.

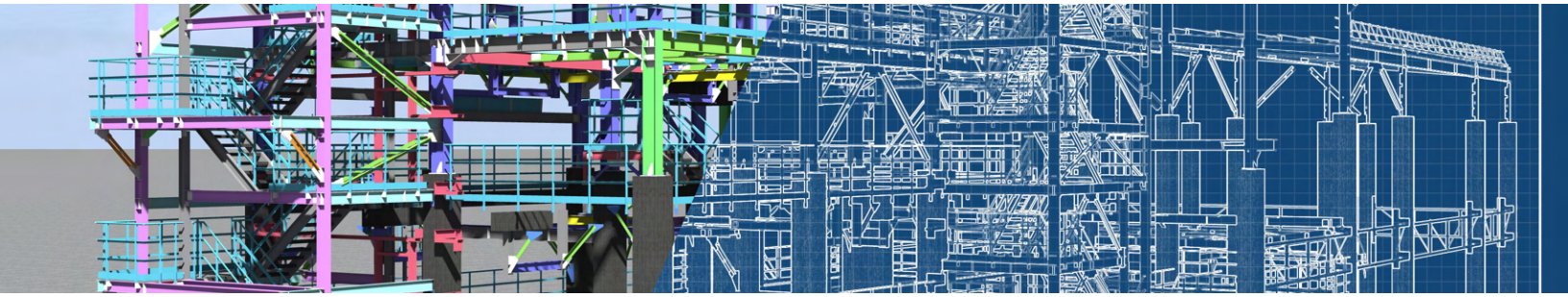
3D PRINTING CONCRETE, STEEL, AND POLYMER

The Chinese company Winsun has been able to build full houses with concrete and other recycled materials using a huge 3D printer. The company clarified that the project was successful in saving 60% of construction materials, 70% of the estimated time, and 80% of the labor.

Joris Laarman had designed, in collaboration with MX3D, a steel printer that is used to print an entire bridge at the MX3D for the Oudezijds Achterburgwal in canal in Amsterdam. The printing process started in 2015.

Polymer Printers were first established in 2007 by the Professorship for Architecture and Digital Fabrication at ETH Zurich. In the beginning, off-shelf polyurethane (PU) foam was used as a printing material. It was printed layer by layer and hardened by heat with 30 cm per minute speed. This polymer printer is convenient and can be occupied to produce the doubly curved meshes, and to construct extreme cantilevers as a porous material.





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This document is intended to create and recommend how to construction organizations invest in construction and design technology.

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