BE322346

Mining and Heavy Industrial Projects Using the Architectural, Engineering, & Construction Collection

Steven Matschke, A.Sc.T.
Design Systems Coordinator
Structural Designer
Stantec Consulting Ltd

Learning Objectives

- Learn about how the AEC Collection can be used to execute heavy industrial and mining projects
- Discover how Revit, AutoCAD Plant 3D, Navisworks, and other software pieces can be used for facility design
- Learn about how Revit can be used for industrial facilities engineering projects
- Gain an understanding of how BIM execution planning can be used on brownfield projects

Description

Learn how engineers and technologists in Saskatchewan, Canada, are innovating in the design of heavy industrial and mining facilities using some of Autodesk's most innovative engineering technologies, such as Revit software, AutoCAD Plant 3D software, Advance Steel software, Navisworks software, and more.

Although many people may think of Saskatchewan as the breadbasket of Canada—thanks to its vast areas of arable land and rich soil used to grow wheat, canola, and chickpeas—Saskatchewan is actually home to many other commodities, including oil, potash, uranium, and mined salt. These commodities have encouraged a highly competent and skilled engineering community to develop within the province, and with these professionals has come a competitive environment with advanced technology and innovations to match. In the last 10 years, an industry boom has sparked billions of dollars of investment into Saskatchewan's mining industries, and the innovations found throughout this time continue to live on today.

Speaker(s)

Steven Matschke is an Engineering Technologist with 10 years of experience as an engineering consultant in the Canada's heavy industrial and mining industries, particularly with Potash, Uranium, and Canola processing facilities. Steven has extensive experience using Autodesk software in the design of complex mining and heavy industrial structures, as well as developing BIM execution strategies for executing this work.

Steven is currently employed in Stantec's Mining group in Saskatoon, Saskatchewan.

Introduction to the Author

My name is Steven Matschke, and I'm an engineering technologist with 10 years of experience working on engineering design projects in the heavy industrial and mining industry. I've worked on multiple expansion projects and hundreds of sustaining capital projects on facilities that produce Potash, Uranium, Canola, Salt, and more. I love to learn new things and I have a passion for tinkering on the never-ending variety of projects (both work and personal) available to me.

When I started my engineering education 12 years ago, I had enthusiastic dreams of one day designing bridges and large skyscrapers that would have a benefit to society. This dream pushed me through the academic system, but I was quickly surprised to find that skyscrapers were only one piece of the civil engineer's capabilities, and that these buildings were typically being designed by large companies in large cities found throughout the world. Some of my favorite structures locally had, indeed, been designed by professionals living outside of my province.

As I started my first job working in the industry, to my dismay, jobs designing skyscrapers and bridges were just not flying off the shelves; rather, what was available in my local industry was heavy industrial and mining jobs. As I grit my teeth and took an opportunity that was no where near to my romanticized vision of where I thought I'd be after school, I took my first role as a building design professional, working as a Structural Designer. I remember thinking to myself, "I'll only do this for a couple of years and then I'll move on to another firm where I'll do more exciting things", but, as fate would have it, I fell in love with the working environment I was practicing in. Many of the challenges I was dealing with were massive and extremely challenging which provided me with a great amount of job satisfaction.

It was this challenge, intrigue, and satisfaction that grew into a fascination with commodities and the problems found within the engineering and construction industries surrounding them. Project problem solving turned in to industry problem solving which eventually led me to pursue a degree in Engineering Technology Management that would lead me to where I am today.

Confidentiality and this Presentation

No, don't worry, there is no confidentiality agreement associated with this paper; rather, there is an associated confidentiality to the work and projects executed in Saskatchewan's mining industry that needs to be considered. Due to the highly competitive and, many times, confidential nature of projects executed in the heavy industrial and mining sectors, I cannot provide any project information that is not accessible to the public. Any ideas or information provided in this presentation is entirely based upon the opinion and experience of the writer, including a period of academic research and local industry review.

Many of the thoughts and ideas presented here are processes that have evolved and developed based on the entire Architecture, Engineering, and Construction industry and how they've been adapted to the Saskatchewan engineering environment, so you'll notice throughout this handout that I don't specifically mention particular projects or problems that were solved, rather the ideas presented here are meant to push industry alignment and provide understanding of how Building Information modeling (BIM) can, and should, be used.

Saskatchewan – A Province of Lakes and Commodities

Today I'd like to tell you a story. I'd like to tell you a story about the province that I call home, Saskatchewan, and some of the massive changes that have occurred in our local engineering industry within my time working in this local industry.

Saskatchwan, Canada, is the where I was born and raised. A province with 651,000 km^2 of land (roughly the same area as Texas) with an approximate population currently of approximately 1.2 million people (only $1/25^{th}$ the population of Texas). The classic joke in Saskatchewan is, "you can sit on your front porch and watch your dog run away for days" due to the large amounts of flat prairie land that is found in the southern part, which is also the highly populated part, of the province.

Although these statements capture one perspective of our mostly flat province, they miss on advertising some of the most important parts of Saskatchewan. The people of Saskatchewan have found a home in vast farm and grassland, boreal forests, an immense amount of lakes, river valleys, and, perhaps not least, commodities, as illustrated in Figure 1.

Saskatchewan Facts:

Population: **1.2 million**	**World's largest** producer of potash
GDP: $**82.5B CAD** ($62.8B USD)	**2nd largest** oil producer in Canada
Land mass: **651,036 km²** (251,366 mi²)	**34 million** hectares of forest
100,000 lakes	**40%** of Canada's cultivated farmland

Figure 1 - Saskatchewan Facts - Retrieved from https://www.saskatchewan.ca/business/investment-and-economic-development/economic-overview

Saskatchewan is the type of province where people can spend a warm summer day in July on the beach bathing in the sun on Saskatoon's river shoreline, with the temperatures hitting plus 30 degree Celsius (86 Farenheit) weather, as shown in Figure 2.

Figure 2 - Typical summer day in Saskatoon, Saskatchewan - Retrieved from https://www.todocanada.ca/things-see-saskatoon/

On the other hand, Saskatchewan is also the type of province where the trees and rivers freeze over in Decemenber and January, as shown in Figure 3. It's not out of the ordinary for temperatures to hit -40 degrees Celsius (which is also -40 degrees Farenheit!) during the winter months.

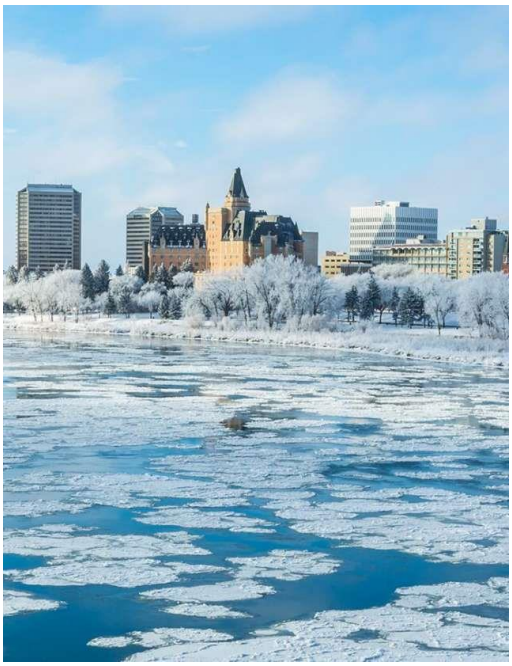


Figure 3 - Typical winter day in Saskatoon, Saskatchewan - Retrieved from https://www.tourismsaskatoon.com/plan-your-trip/tools-and-tips/weather/

During these cold periods, you'd think that people would hide indoors and pump their heat up to compensate for the cold outside… And you'd be right! But that doesn't mean that everything

comes to a halt. For example, here's a picture of Saskatchewan's Federated Co-op workers during last years strike, which overlapped with some of the coldest weeks of the 2018/2019 winter. Our willingness to live and survive in this highly changing environment is something that I believe makes our province so versatile and nimble, and I believe this plays a role in the capabilities of our engineering professionals.

Figure 4 - Typical winter strike in Saskatoon, Saskatchewan - Retrieved from https://thestarphoenix.com/news/local-news/saskatoon-co-op-strike-continues-after-union-votes-against-newest-offer

As I alluded to earlier, one thing that is usually missed when people talk about this province is the large amount and variety of minable commodities available within our borders. Saskatchewan is the second largest oil producer in Canada, and, perhaps more importantly, is the largest producer of Potash and the second largest producer of Uranium in the world!

Industry in Saskatchewan

Saskatchewan is a province that is made of a variety of exportable commodities, many of which are mined goods, such as Potash and Uranium, as shown in Figure 5.

Figure 5 - Top Export Products of 2018 from Saskatchewan - Retrieved from https://www.saskatchewan.ca/business/investment-and-economic-development/economic-overview

To provide a bit more information here, Saskatchewan's Economic Overview web page states, "Saskatchewan exports totaled $30.7 billion in 2018. The United States (U.S.) is Saskatchewan's top export market, receiving almost 50% of total exports. China is the second-largest export market followed by Japan, Brazil, and Mexico.", as received from https://www.saskatchewan.ca/business/investment-and-economic-development/economic-overview.

Although Oil is still the top export in Saskatchewan according to the 2018 data, the majority of my professional experience lies in our other major exports: Potash, Canola, and Uranium. These commodities have many processing and mining locations, as well as many supporting services, found throughout the province.

To provide an idea of the value of these exports for Saskatchewan, ~27% of Saskatchewan's GDP is directly gained from the mining, quarrying, and oil and gas extraction industries. Beyond that construction, manufacturing, transportation, and educational services, all providing support to the mining industries, further benefitting and developing the local economy, as shown in Figure 6.

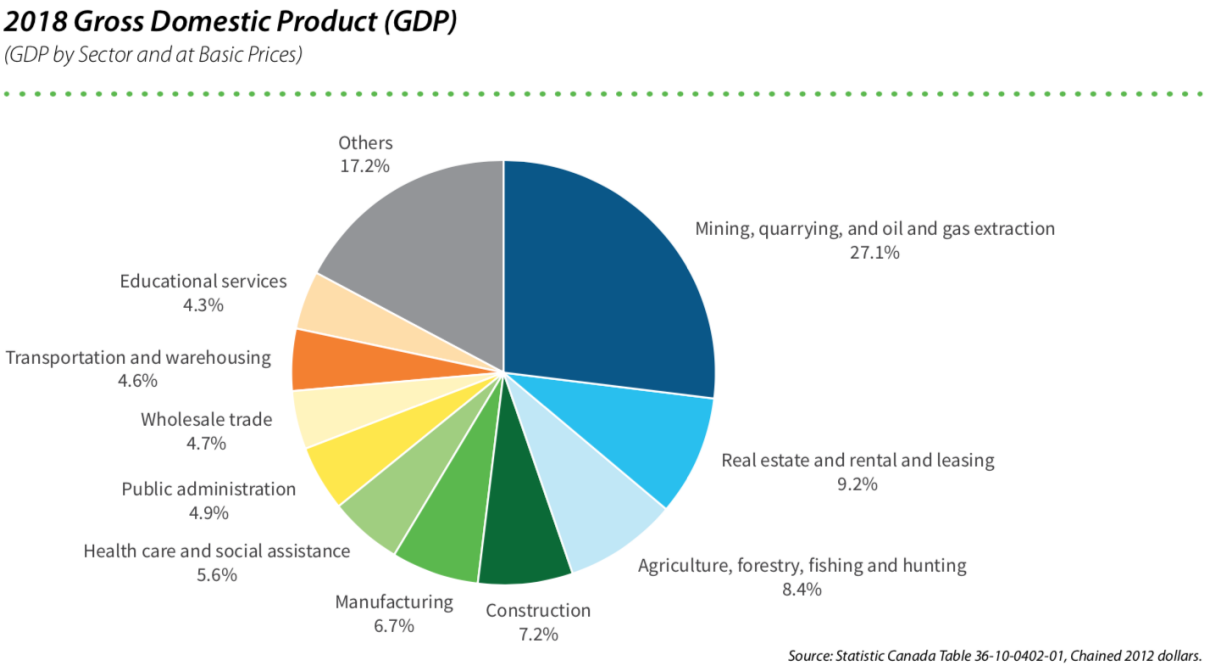


Figure 6 - Saskatchewan GDP by Sector - Retrieved from https://www.saskatchewan.ca/business/investment-and-economic-development/economic-overview

Although there are many exports and commodities in Saskatchewan, to simplify the story of how engineering technology in the province evolved to where it is today, the rest of this document will focus on the Potash industry in Saskatchewan and the many projects found throughout that industry.

The Saskatchewan Potash Industry

What is Potash?

Before we dig into the complexities of engineering design projects using Computer Aided Design (CAD) and Building Information Modeling (BIM) on industrial projects, let's take a moment to understand the local industry further.

The potash industry is complex and would require complicated process flow diagrams and in depth explanations to illustrate the processes involved; so, instead, what better way to show off a broad overview of the facilities and production methods than by showing one of my favorite TV programs, *How it's Made*! Thankfully, How it's Made has done me a significant favor by creating an episode for the Potash mining environment:

How it's Made – 1376 Potash
By: How Its Made
https://youtu.be/XELGBB-jqNQ

Note: As you watch this video, take note of some of the typical items that may be designed by an engineering professional. What type of things do we see?

- Structural steel,
- Concrete,
- Mechanical equipment,
- Piping,
- Electrical,
- Building Finishes,
- And much more!

Another Potash mining site, K+S Bethune (previously known as the K+S Legacy Project), has a much more unique way of acquiring their Potash, known as "solution mining":

K+S Legacy Project Potash Mine
By: Sask Wanderer
https://www.youtube.com/watch?v=6Bpi21BovNw

This environment is a very typical production environment. Potash projects are typical to other engineering design projects found throughout the Architectural, Engineering, and Construction (AEC) industry, which many times uses a Design-Bid-Build process to procure an engineering team to design a solution, that solution is bid out to construction professionals, and the preferred professional is chosen to execute the work.

Although there are a variety of industry secrets that I can't dig into further here, taking a moment to realize the normality's of the Engineering and Construction industry and how they could be applied here, in the Potash industry, is important to be able to create a correlation between our industry and your own.

Potash has been the backbone of the Saskatchewan economy for several generations. The iconic tailings piles, which can be seen while travelling on many of Saskatchewan's rural highways) provide man-made mountains that occupy an otherwise flat prairie landscape. Many of the Potash mines scattered throughout the province, as shown in Figure 7, have been functioning for over 60 years, and, throughout their life-time, have provided undeniable positive economic flow into the many communities found throughout the province.

Figure 7 - Typical Potash Mine, Nutrien's Rocanville Site - Retrieved from http://www.canadianminingjournal.com/news/potash-potashcorp-competes-rocanville-expansion/

Along with the job positions created at each mine, there have also been a variety of jobs created for the services industries that support them, like businesses providing engineering, construction, and manufacturing services. For the engineering industries, the experience gained by the professionals working in Saskatchewan has provided them with world class knowledge in the design of mining facilities. These skills have granted Saskatchewan's engineering professionals the experience to tackle seemingly any engineering problem… but nothing could prepare the industry for the challenges to come in 2008; the beginning of, "The Potash Boom".

The Saskatchewan Resource Boom

In 2003, Saskatchewan's acting New Democratic Party, aka the "NDP", government made major changes to the potash production tax system. According to the Saskatchewan Chamber of Commerce, the "2003 amendments exempted companies from the profit tax payments on sales above their 2001-2002 average and allowed for faster capital write-offs. The goal of these initiatives was to help the industry realize its immense growth potential" (Retrieved from Saskatchewan's Potash Royalty and Mining Tax Regime, 2011).

If this wasn't enough to get the local economy going, in 2005 two more amendments to the potash production tax system occurred, which provided "a base-payment holiday of 10 years for new production from mine expansions exceeding 122,000 K2O tonnes per year was established, and the depreciation rate on capital expenditures in excess of the base, defined as 90% of 2002 capital expenditures, was increased to 120%" (Retrieved from Saskatchewan's Potash Royalty and Mining Tax Regime, 2011). To simplify these rather technical policy items, what this really meant was that the potash companies in Saskatchewan were able to invest in an expansion that was completely supported and sponsored, both socially and financially, by the local government.

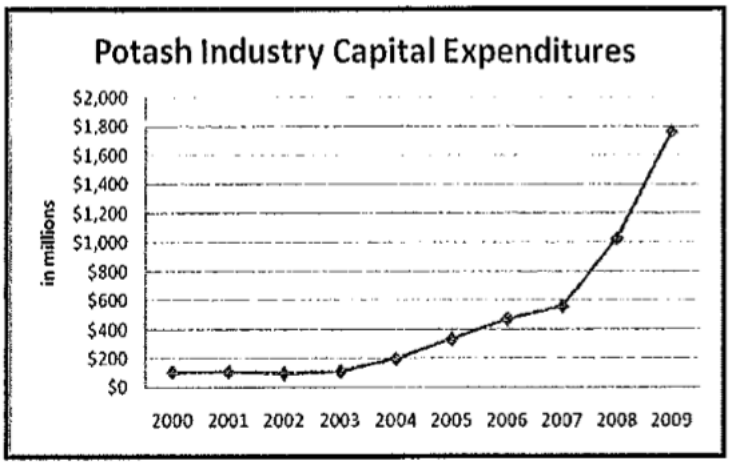


Figure 8 - Potash Industry Capital Expenditures - Retrieved from Saskatchewan's Potash Royalty and Mining Tax Regime, 2011

The result of these changes were an increase in capital expenditures in the potash industry to grow "from $107 million in 2000 to $1.76 billion in 2009" (Retrieved from Saskatchewan's Potash Royalty and Mining Tax Regime, 2011), as seen in Figure 8. When much of the world was feeling the effects from the commodity boom and bust, and the decline during the global economic crisis of 2008, Saskatchewan's economy was ramping up and preparing itself for one of the most economically productive decades it had every experienced.

Expansions and projects were planned at every mine site in some capacity, and greenfield projects like, K+S's Bethune mine were also established, as seen in Figure 9 & Figure 10.

Figure 9 - K+S Bethune Mine - Retrieved from https://www.ks-potashcanada.com

Figure 10 - Evaporators in the wet dry area of K+S's Bethune Mine - Retrieved from https://www.680news.com/2017/05/02/ks-opens-new-potash-mine-first-new-mine-in-saskatchewan-in-more-than-40-years/

The results of these investments were seen across Saskatchewan. According to SREDA's 2008 Q4 Saskatoon Region Economic Report, the "Saskatoon region was the fastest growing metropolitan area in Canada… [with a] GDP growth of 5.4 percent… [where] Mining and Wholesale and Retail Trade sectors all experienced significant growth" (SREDA, 2008). New business start-ups were popping up, new housing builds and subdivisions were being developed in many of the provinces city centers, and unemployment rates were at an all-time low. This period of economic prosperity was noticed worldwide as the US felt the pinch following the burst of the housing bubble around the same period, so Saskatchewan sat on the world stage as others looked in.

Changes to the local economy began to impact commodity prices and Potash prices expanded drastically. Potash production companies, like PotashCorp of Saskatchewan (PCS) and Agrium (now combined to become Nutrien), K+S Potash Corp., and Mosaic all put great pressure on their service providers, hoping to mine and sell as much potash product as possible in an effort take advantage of the high commodity prices available to them.

As a young professional just getting out of college in 2010, this was a very interesting and challenging time. In the engineering consulting world, where I started out my career, large engineering giants, such as SNC Lavelin, Hatch, and TetraTech, moved into the province and multiple small engineering consulting startups were founded. Engineering consulting services were booming, with each potash producer looking to get as much product sold as possible, the prerogative across the industry was to adopt technology as fast as possible to become as efficient as possible. As the demand for more efficient and advanced technologies began, change happened. It happened rapidly, it happened strategically, and, many times, it happened frantically.

Innovation in the engineering industry happened so quickly that no one could have been prepared for what happened next. Implementing some of the worlds most advanced software needed to take place yesterday. Autodesk software, an industry standard, began being used in new and innovative ways with the adoption of Revit, Inventor, and Navisworks. New software providers like Aveva, Trimble, and Bentley began establishing themselves with the promise of providing software that could efficiently align large project teams.

Our industry professionals designed a whole new potash mine, expanded on several other mines, and continued to do work outside of Potash for our local industry throughout that period. Eventually, as per the rollercoaster ride that is economics, the industry slowed down and potash prices diminished. Potash commodity prices rose and fell to a normal state, as shown in Figure 11.

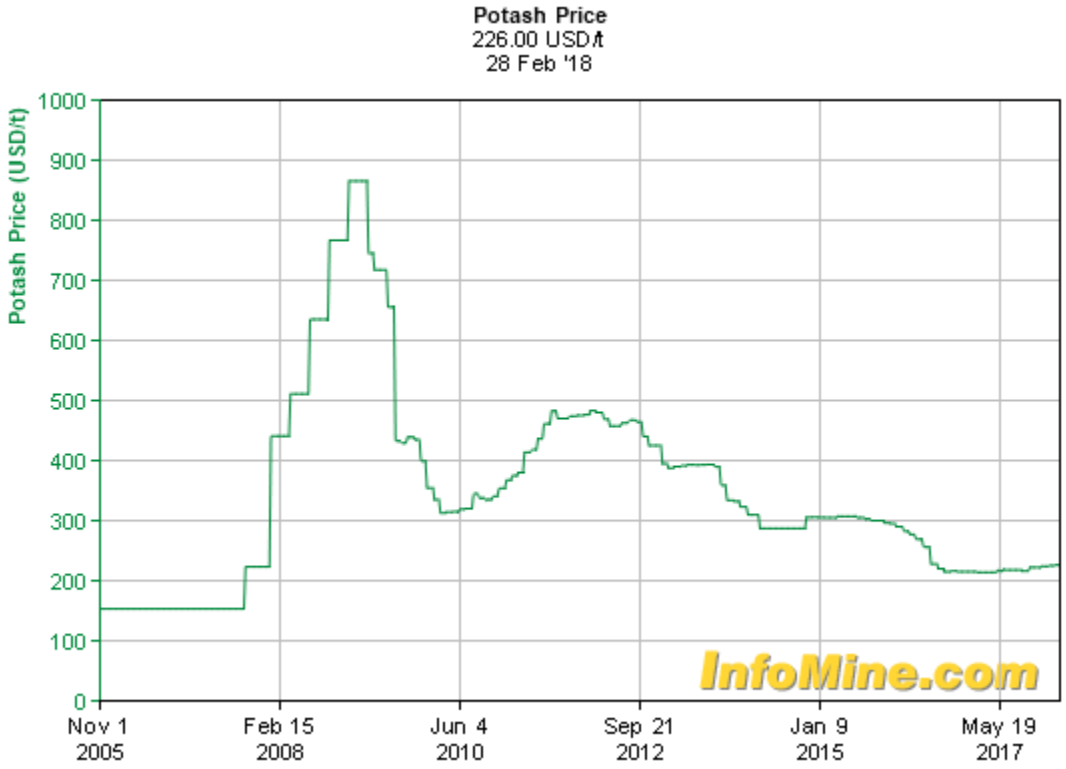


Figure 11 - Potash Historical Commodity Prices – Retrieved from Infomine.com, 2018

The once deep pockets that were found during the boom were now showing signs of emptying, and many companies began to feel the extra weight that they had put on over the years. Many companies found that their newfound tech was pushing the now thin budgets available to them and began to question the validity of their purchase.

“Do I really need all this software?”
“Could I cut the software and save myself a lot of money?”
“Do I need 3D models to execute projects?”
“Do I need to create drawings to execute projects when I have a model?”
“Could we create a 3D model that would just replace all these 2D drawings?”

These were the questions being bounced around by industry professionals.

So, here's where I came in. As the dust began to settle in the industry, I began working on academics to acquire a Bachelor's degree. Conveniently, I was challenged to execute an academic thesis that would endeavor to solve some of the growing pains our industry felt during the boom. Many, if not all, of the technologies we as engineering professionals had adopted were available to the industry now, and it quickly became apparent that these technologies could and should be used to improve how we were executing projects. Based on the support of my peers, I began exploring how our Heavy Industrial and Mining Industry of Saskatchewan could provide 3D models as the primary project deliverable.

One example of an issue that continued to arise for our local professionals was how little our deliverables would be shared between project stakeholders. It was very normal for an engineering consulting team to create a 3D model of a structure, only for the fabricator to take that 3D model, decide not to use it because they couldn't trust the information in the model, and create their own model. Inefficiencies like these were a real struggle for our professionals. Interoperability frustrations were frequent and confidence in other designers' models was just not there.

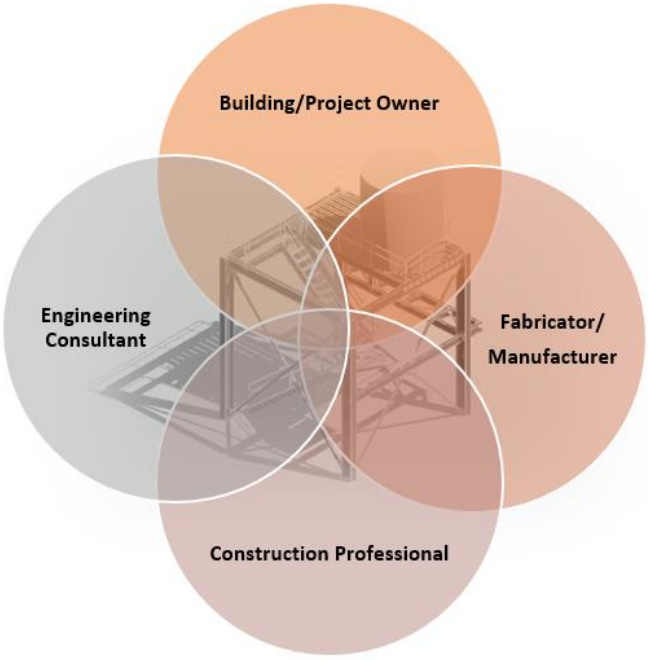


Figure 12 – Framework of how Saskatchewan's engineering and construction professionals wanted to work

After spending years conducting research, months interviewing professionals, and even more months writing a thesis, here's what I found:

1. When our professionals were wondering how they could create intelligent models that could be delivered at the end of the project, what were they asking for? **They were asking for BIM!**
2. When our professionals were struggling to identify how they could create 3D models and communicate them between project stakeholders, what were they looking for? **They were looking for a BIM Execution Plan!**
3. When our professionals were struggling to identify how much information should be placed in a model, what were they looking for? **They were looking for a Level of Detail (LOD) standard!**

At this point, I took a step back. Wow! I did it. I solved the puzzle. An answer that seemed so obvious that had been sitting in front of us the whole time. BIM!

But had I solved the puzzle? I had simply just identified that BIM technology was the solution to this problem, and now it was time to fully understand and implement this technology.

BIM Technology and its surrounding software requires training and time to get an individual knowledgeable enough to execute work, BIM Execution Plans are a new way of thinking of project execution that challenges everyone from designers to project managers to re-evaluate how they are executing their project, and the LOD standard is a very daunting and challenging standard that can make our break a project's success!

It didn't take me very long to realize that I had just opened a can of worms, and this problem has since completely grasped on to my career. I was once a simple Engineering Technologist drawing lines and circles and exploring in the world of 3D models, and now I have this knowledge about BIM that needs to be communicated to others in our industry? I'm just exhausted saying it. So, that's where I am today. And that's why I created this document.

To end this section, let me introduce you to a proverb provided in the book BIM and Construction Management by Hardin and McCool that I believe illustrates our frustration with growing technology in an industry established 50 years ago:

"OO + NT = EOO (Old Organization + New Technology = an Expensive Old Organization)"

Let's change that.

BIM Technology

BIM Technology is not a product, it's a societal phenomenon. Treating it as a science, similar to that of project management science, is the key to its success.

Technology Delivery Process and BIM

Most organizations have a formalized technology delivery process, whether they know they do or not. Typically, this delivery process flows from the initial inception, to assessment, to delivery and management, to eventual disposal/replacement, as shown in Figure 13.

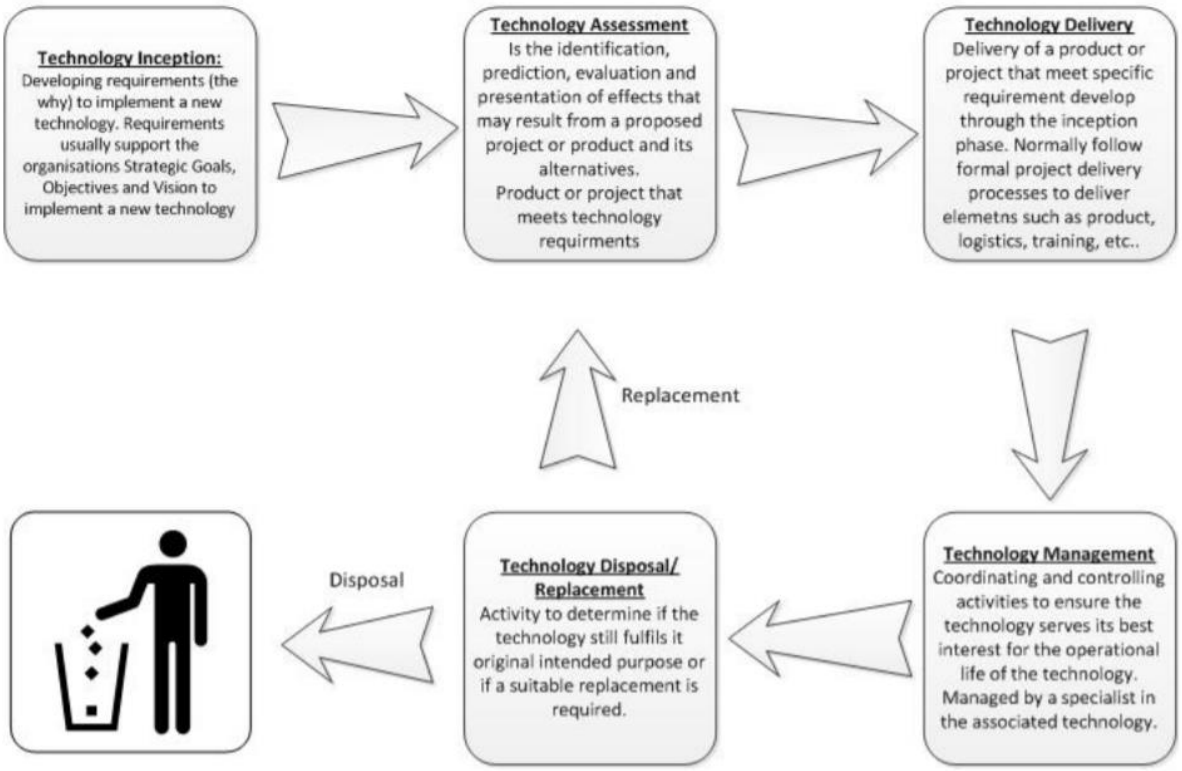


Figure 13 - Typical Technology Delivery Process

When we talk about BIM, what we really are talking about is a technology. Many times, when we think of technology as smart phones, computers, LED TVs, the internet, and modern electric vehicles. These are all technologies, but it is important to understand that technology is a very broad field that encompasses a vast number of different products, processes, and solutions.

There are many definitions of what technology is. One of the best definitions of technology among academic critics of technology is from bush, who says "Technology is a form of human cultural activity that applies the principles of science and mechanics to the solution of problems. It includes the resources, tools, processes, personnel, and systems developed to perform tasks and create immediate particular, and personal and/or competitive advantages in a given ecological, economic, and social context." - Bush, C. L. (1981). Taking hold of technology: Topic guide for 1981–1983.

Beyond the core technology, there is also innovations in that technology. Technological innovations are incremental improvements to that technology that eventually improve to the point where it becomes viable or make it even more efficient.

Perhaps the best example of this is the modern internal combustion engine. The internal combustion engine has gone from carburetion to fuel injection, from cast iron blocks to aluminum blocks, from large pushrod displacements to small dual overhead cam-based engines, all of which are incrementally more efficient than the last.

As battery technology becomes more and more viable, we are starting to see the automobile industry change with new electric vehicles popping up at a very rapid rate. It is only a matter of time before the innovations in battery technology get to the point where they will be able to completely overcome the internal combustion engine. That being said, at some point, we may run low on lithium, or find another material that causes issues to our environment or the health of our society, which will spark a new technology or innovation to replace that problem. These cycles are inevitable, and these cycles are what makes our human society so capable of solving complicated and complex problems.

Understanding BIM

Understanding BIM technology requires a deep dive into the history of building construction and how it relates to current building design and construction. This is a topic that could be covered in a length paper, but, thankfully, it is also captured very well in two book publications:

- BIM and Construction Management, by Hardin & McCool, and
- The BIM Handbook, by

I highly recommend reading these two books for anyone who wishes to know more about how BIM Technology became a thing. In a nutshell, the five steps that led to BIM are:

1. Emergence of the Master Builder
2. Advent of 2D Drawings and early Information Modeling
3. Fragmentation in the Industry
4. The Advent of Computer-Aided Design (CAD)
5. Emergence of Parametric Modeling and Building Information Modeling (BIM)

Although this is a brief summary of information, what is important to understand is that BIM has had a foundation much before our modern CAD technology ever emerged. BIM is a response to a technological problem identified by our ancestors, and it's one that we are just now finding the answers to.

AEC Collection Relationship

There is a direct correlation between investment into a commodity and the technological innovation that happens in that industries local economy. For our local industry, this was no different.

Let's take a step back to the beginning of the boom. As the years pass and large projects begin, many different software providers emerge and establish themselves in the local industry. Autodesk AutoCAD and Bentley Microstation had historically been the foundation of how engineering projects were executed using CAD, but now this was changing. No longer do we see just Autodesk software in our industry, instead we have software provided from Aveva, Bentley, and Trimble, just to name a few.

The products provided from these different software providers are very powerful and are marketed directly at the heavy industrial mining industries; however, the costs and training requirements to get up and running with these pieces of software is many times difficult to digest and crippling for the execution of projects and adoption by companies both large and small. So, for this next section, I want to answer a question that I have heard mentioned in many casual and professional conversations, "Autodesk software can't be used for large scale industrial projects".

Autodesk's AEC Collection

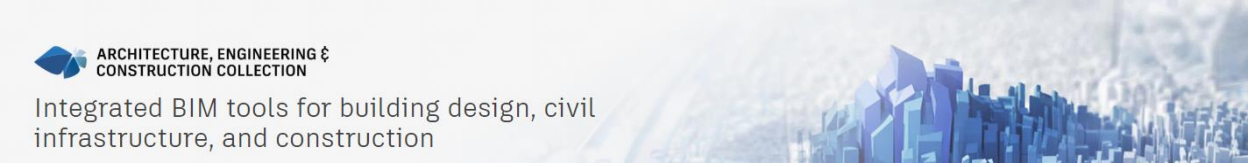


Figure 14 - Autodesk's AEC Collection Webpage Advertising - Retrieved from https://www.autodesk.ca/en/collections/architecture-engineering-construction/overview

Autodesk's Architecture, Engineering and Construction (AEC) collection, as shown in Figure 14, is a very capable collection that allows users to design (in the simplest words I know) anything! From vehicles to skyscrapers, from 3D printing ready models to fully rendered environments, from a house to a massive industrial facility, Autodesk has a software that will check the boxes that any professional designer could ask for. The AEC is a collection of all the software needed to work on an AEC project, nicely wrapped up in one package for users to purchase and use on their projects.

Discuss the Software Relationship

No one software does everything perfect in the AEC collection, but combined they can accomplish anything!

Based on my experience, this is how I think of them:

- Revit is a great structural design tool, but it struggles when finely detailing components, such as detailed pieces of equipment
- Inventor is great for detailed equipment design, but struggles with large scale plant layout items, like piping, HVAC, and large structures
- Plant 3D works great for piping and P&ID's, as well as working well with Autodesk software, but struggles with structural drawing creation

- Advance Steel is a great structural detailing software that allows for powerful workflows for creating erection diagrams and detailed shop level drawings
- Navisworks is what coordinates all these 3D model creation items and allows you to create an almost unbelievably easy to navigate and understand viewer

Separately they can struggle, but together they are very powerful! Each of these tools is highly customizable and can be adapted to any project hurdle that you may run in to.

Understanding these overall capabilities is the first step to being able to execute a project, but what happens when a project starts to get large, requiring extensive interoperability planning to ensure the software is used correctly? This is when a BIM Execution Plan is required, and this is what you need to ensure you can execute a project successfully when scaling up the AEC Collection.

BIM Execution Planning

It is not normal to just see one or two applications used on a project. It is very normal for an organization to use tens of applications, even for small projects. In early planning, avoid the temptation to use the "this is what we did last time" mentality, or the "we'll figure it out" mentality. Avoid the temptation of adopting a new piece of software and assuming it will immediately solve all your previous project problems. Spend time to review the requirements of the project, look at the BIM capabilities available, gather a team of technical leads to develop the process, and develop a BIM Execution Plan to suit.

The BIM Execution Plan is your plan for how you are going to execute your projects using the software available to your team. If you have access to every software available, that might sound great for providing unlimited capabilities to your team, but it can cause, what I like to call, **BIM Execution Paralysis**. BIM Execution Paralysis is what happens when a project team begins thinking about how they're going to execute a project and, when the hurdles become to big they say "We'll just figure that out later". Whew, that just makes me uncomfortable thinking about it.

How can we prevent BIM Execution Paralysis? Think with the end in mind. BIM Execution Planning in any project environment is possible, even in the ever changing heavy industrial and mining environment that I call home. The most reliable method I've figured out for BIM Execution Planning in our environment is the following:

1. ***Identify your projects BIM Uses***
2. ***Develop your BIM Interoperability Frameworks***
3. ***Identify your Level of Detail (LOD) Standard***

Sounds simple right? Well, if you know what each of those things are, it does! Instead of going through each of these in excruciating detail (there is a large amount of information on these!), lets go through an example and I'll walk you through the process.

BIM Execution Plan for a 100'x100'x100' Process Facility

Let's say your team needs to design a 100' cube structure, as sketched in Figure 15.

The design criteria are:

- 100' cube structure
- 60+ year life, throughout its life it will likely have:
  - Debottlenecking projects
  - Expansions
  - Sustaining capital projects
  - Require a facility management team to manage future projects
  - 100 Mega Ton output
- Mechanical systems
  - Equipment
  - Piping
  - HVAC
- Structural
  - Concrete
  - Steel
  - Building finishes
- Electrical
  - Motor control center
  - Cable tray
  - Instrumentation
  - E&I Diagrams
- Require engineering drawings for project communication

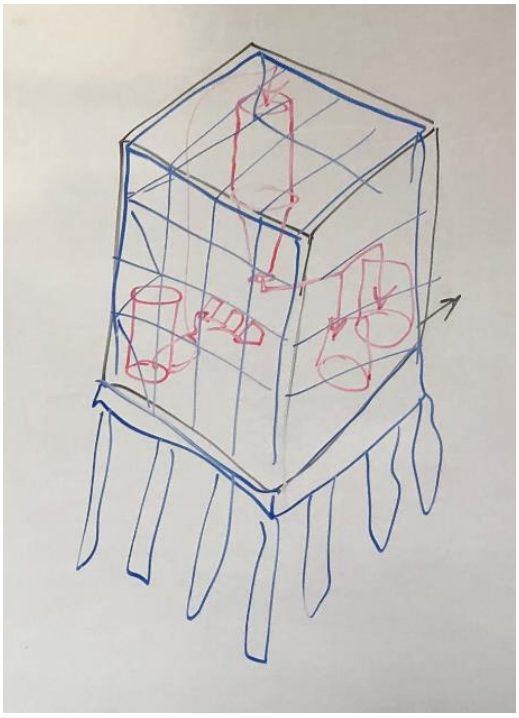


Figure 15 - Project Kickoff Sketch of the Structure

Every project should have a BIM Execution Plan. I mean it! Your small projects and your large projects, the all need a BIM Execution Plan. That doesn't mean it needs to be a written document each and every time, rather it can just be a verbal plan covering all items that should be known and understood by the team.

For this project, knowing the BIM execution process is not likely, so a planning session will be required. Lets reenact each planning session, understand what needs to be covered, and provide a solution.

Step 1: Identify your project BIM Uses

BIM Uses are the ways that BIM Technology can be used to execute projects. One of the most valuable sources I've found in the industry right now for identifying BIM Uses is from PennState's College of Engineering, who has developed Planning Guides for BIM Implementation (as found at: https://www.bim.psu.edu), that identify the many uses of BIM and what needs to be considered when utilizing them. Penn State's list of BIM Uses, as shown in Figure 16, allow for the team to understand and identify which items will be needed to execute a project. Of course, this is not an exhaustive list, but it is a great place to start.

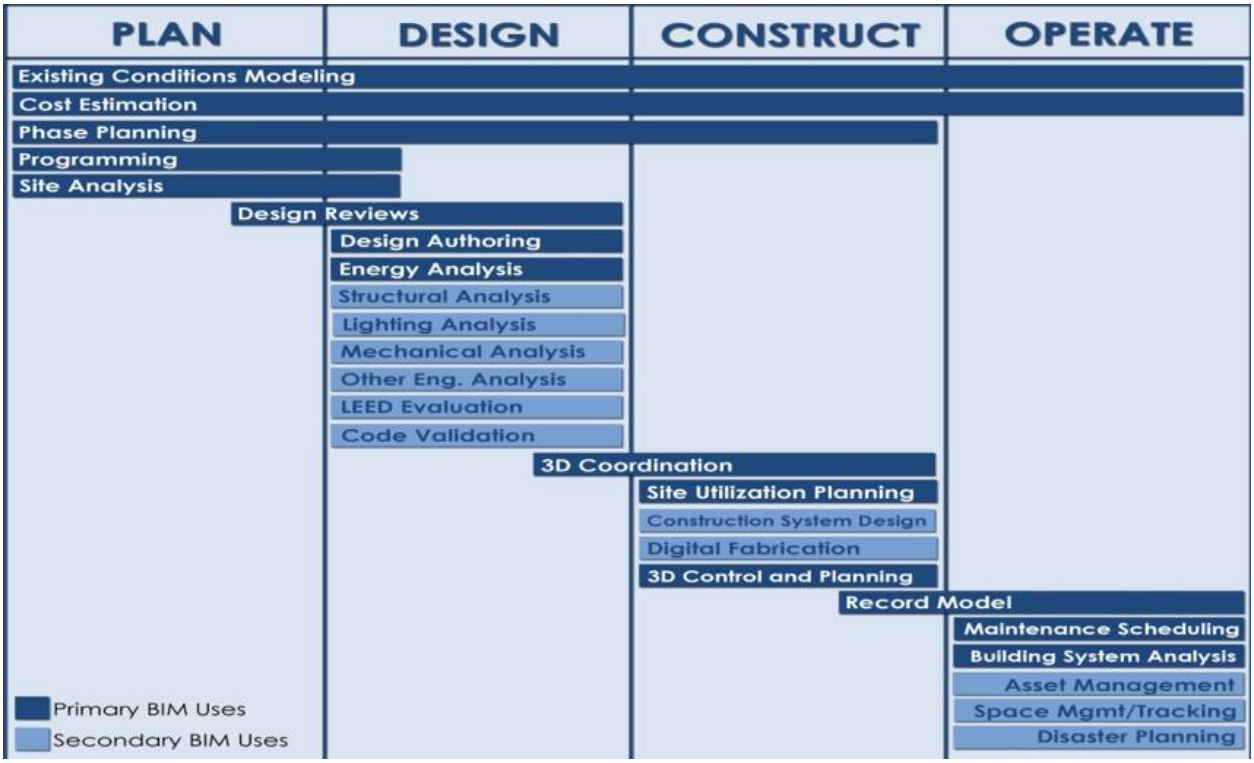


Figure 16 - Penn State BIM Uses Diagram - Retrieved from https://www.bim.psu.edu

For this project, what would make sense for executing the work? Lets go through some typical uses:

- Asset Management
    - Is this model going to be used for future asset management? If so, should this be handled now or later? If later, have you chosen a software that can allow for this?
- Record Modeling
    - Record modeling is keeping a model that is a record of the current as-built status of the facility. This can be provided in a varying level of details, but the important thing here is to understand how the model should be used and communicated for future projects.
- 3D Coordination
    - 3D coordination is the connection of all project model information for visual interaction to complete clash detection. Models must all be connected in one source (usually using a software like Navisworks).
- Design Authoring
    - Which tool will be used to create your building information model? In the case of the structural model, Revit provides exceptional tools for structural modeling

- Engineering Analysis
    - Structural analysis can be performed in a variety of ways, but, luckily, Autodesk provides a powerful working connection between Revit and Robot! These two software pieces can be used to take information out of Revit, analyzed in Robot, and, if set up correctly, changes can be pushed back into Revit!
- Design Reviews
    - Design reviews are one of the AEC industries favorite uses for BIM that benefits the entire project team. Does your team intend to have design review meetings with the client?
- Cost Estimation
    - Does your team need to create cost estimates during the project? How will you utilize the software to accomplish this?
- Existing Conditions Modeling
    - Does your team need to account for changes to an existing structure, or to the existing site? How will this data be acquired and used?

Wow, a lot of things to consider, right? These are some of the questions that you'll need to be able to answer to ensure that your team can execute a BIM project.

The answers to these questions are ones that you'll be able to learn and accomplish through executing projects, but some will require research and development to ensure that they can be accomplished appropriately. That takes us to our next step.

Step 2: Develop your BIM Interoperability Frameworks

One of the biggest hurdles that must be overcome when planning a BIM project is understanding and solving the interoperability requirements needed for project stakeholders to work together. Many times, this is where the BIM Paralysis begins, but it is now that it needs to be solved. Don't worry! Take a deep breath and let's find out how our software is going to work together for you.

Before we dig into that, let's take a moment to understand some fundamentals about BIM Software. The BIM Handbook, as shown in Figure 17, is a great resource for BIM novices all the way to BIM experts due to the many research pieces, theories, perspectives, and case studies provided in this book. If you haven't read it, and you're anywhere from a designer to a manager, I highly recommend it.

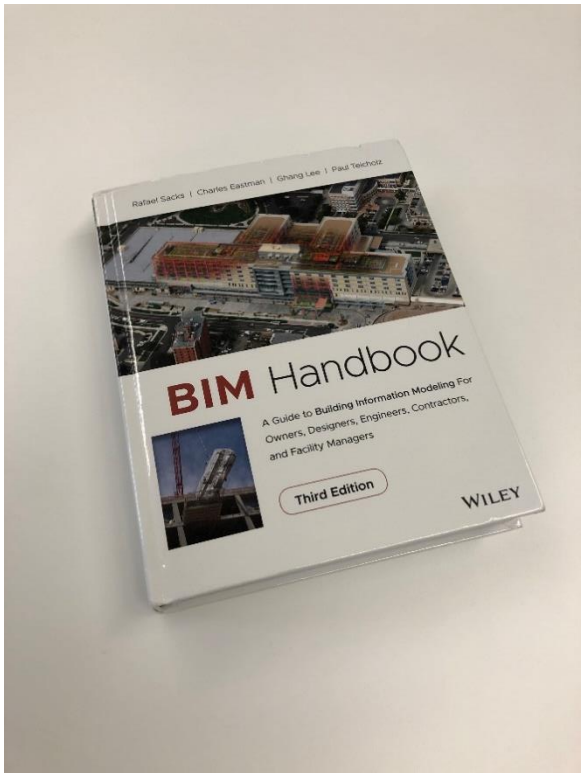


Figure 17 - The "BIM Handbook", now in its third edition

BIM Data Exchange Formats

Data exchange formats are also an important item to consider. In the BIM Handbook, three different data exchange formats are provided:

- Direct Links,
- File-based data exchange's, and
- Model-server based data exchange's.

These exchange formats are important as they are the key to connecting the different pieces of software together throughout the project.

BIM Environment, Platform, and Tools

One of my favorite pieces of knowledge presented in the BIM Handbook is how it captures the relationship of each BIM product as it relates to BIM as an overarching technology. The BIM

Handbook states that there are three different items when considering BIM software: the BIM Environment, BIM Platform, and the BIM Tool.

The relationship between these different BIM entities is captured using this diagram in the BIM Handbook, as shown in Figure 18. As you can see, the relationship between all the BIM framework items is a daunting and, many times, confusing for project professionals to understand. On heavy industrial projects, this diagram could spiral out of control as many project stakeholders become involved.

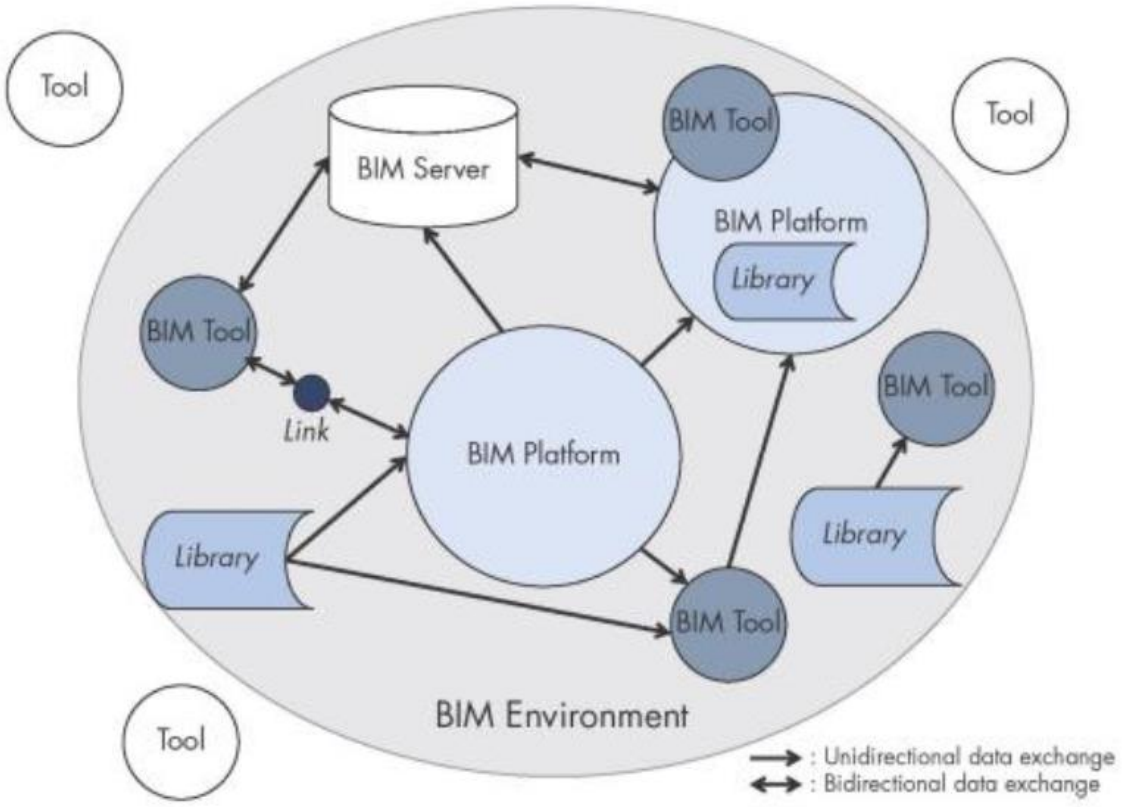


Figure 18 - BIM Environment, Platform and Tools relationship as defined in the BIM Handbook

I find that the information in this diagram can get confusing, so I've adapted the execution diagram to allow for it to really meet the requirements of project planning sessions. My process uses a similar diagram to the one above, but it allows for project stakeholders to be identified in a bit more organized fashion, as shown in Figure 19. I call this BIM Interoperability Framework, a tool for planning project interoperability that can be scaled as big as your project requires.

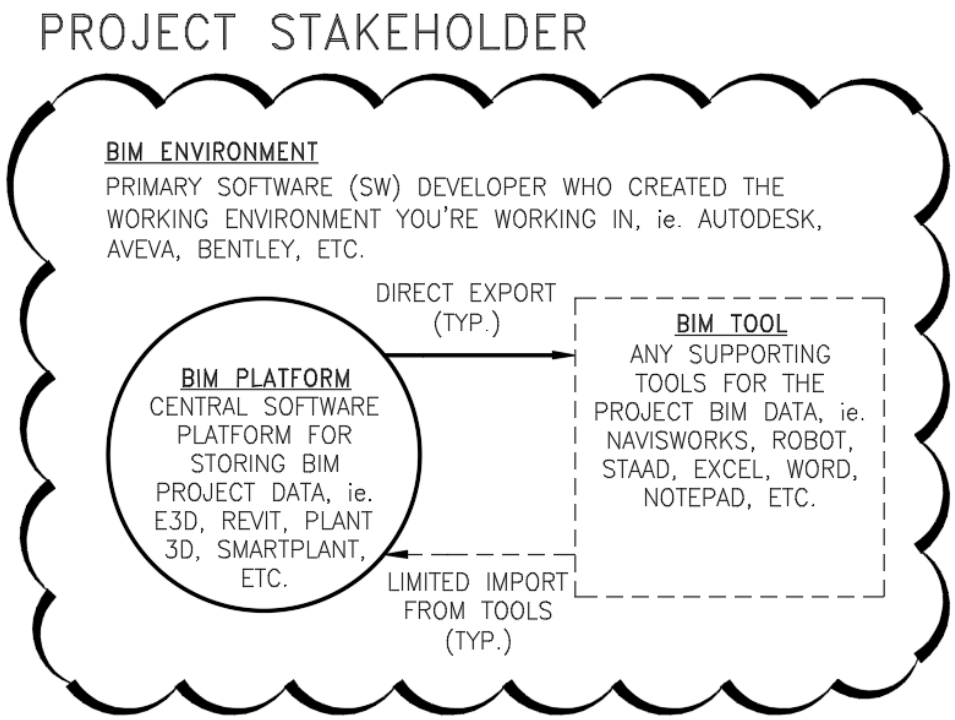
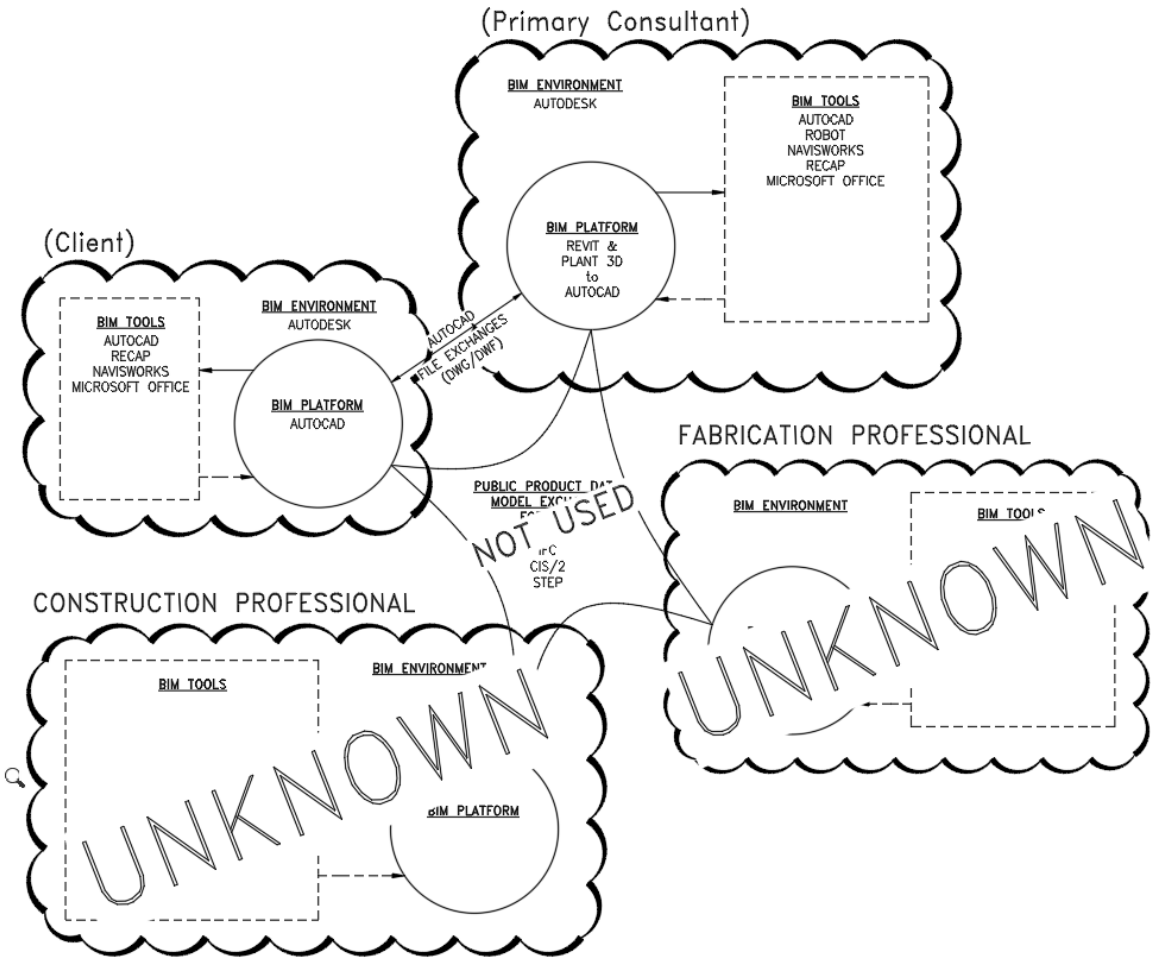


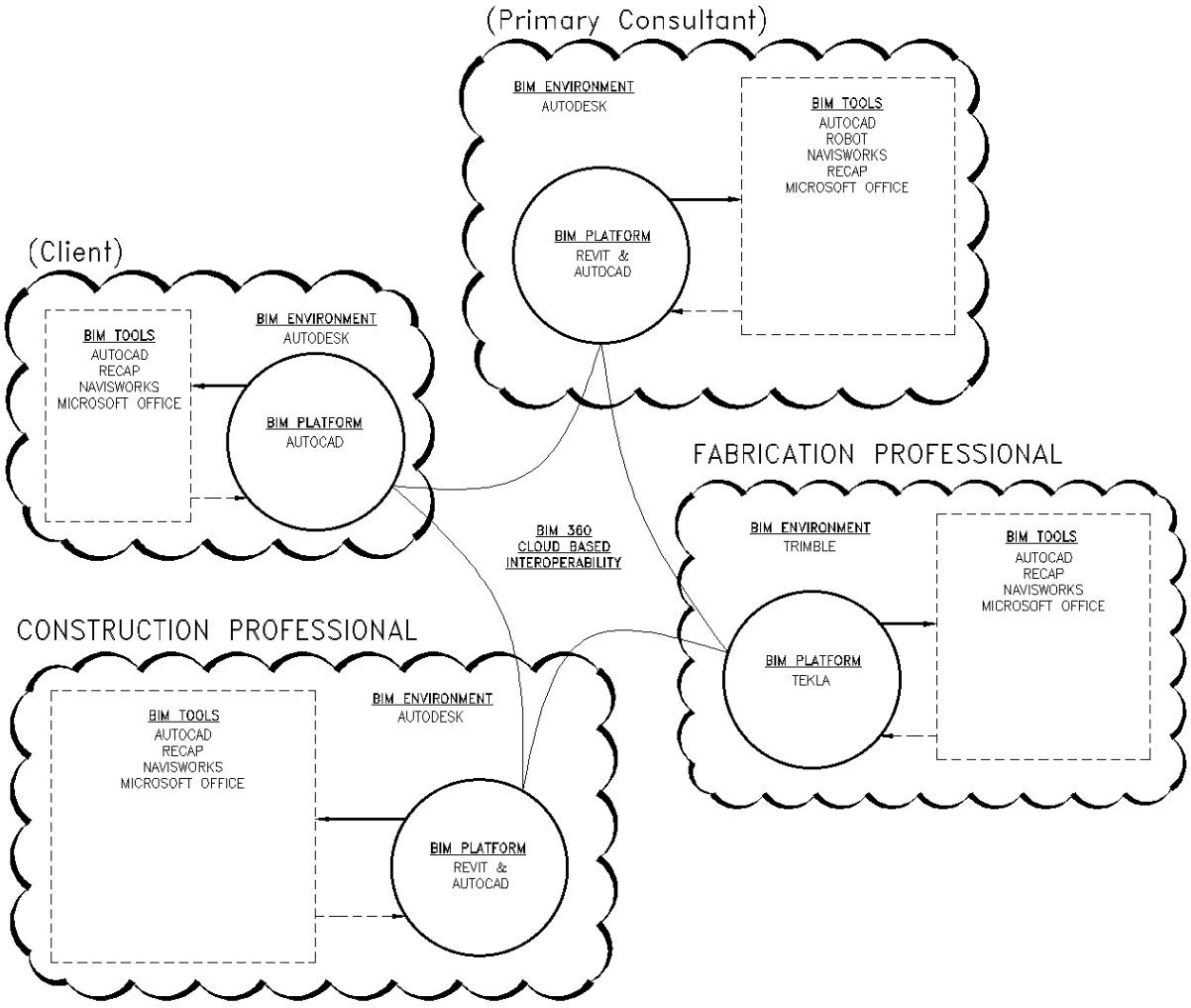
Figure 19 - The BIM Interoperability Framework

Let's look at a couple examples of what a project BIM Interoperability Framework can look.

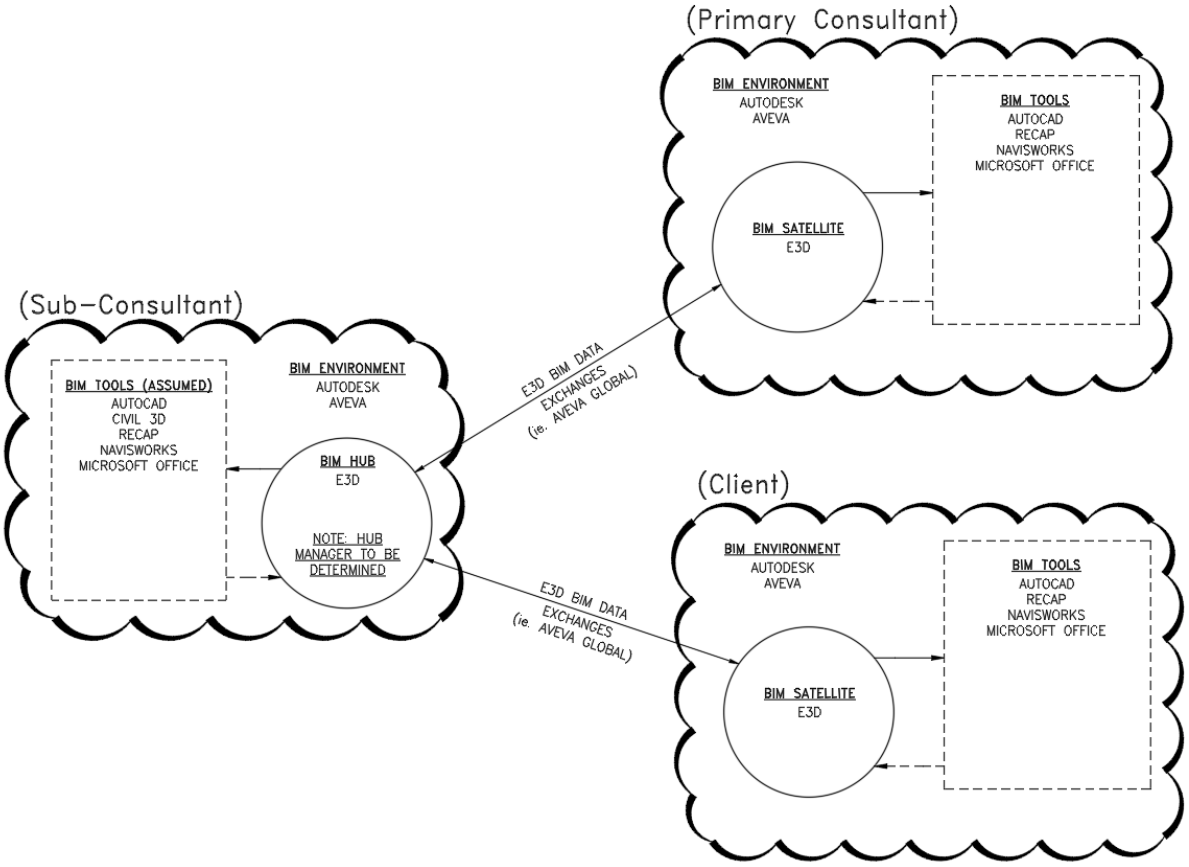
Here's an example of a Design-Bid-Build project that comminucates project information using a Direct Link BIM data exchange format. In this image, as per a Design-Bid-Build project, none of the other project stakeholders are available during the engineering project.



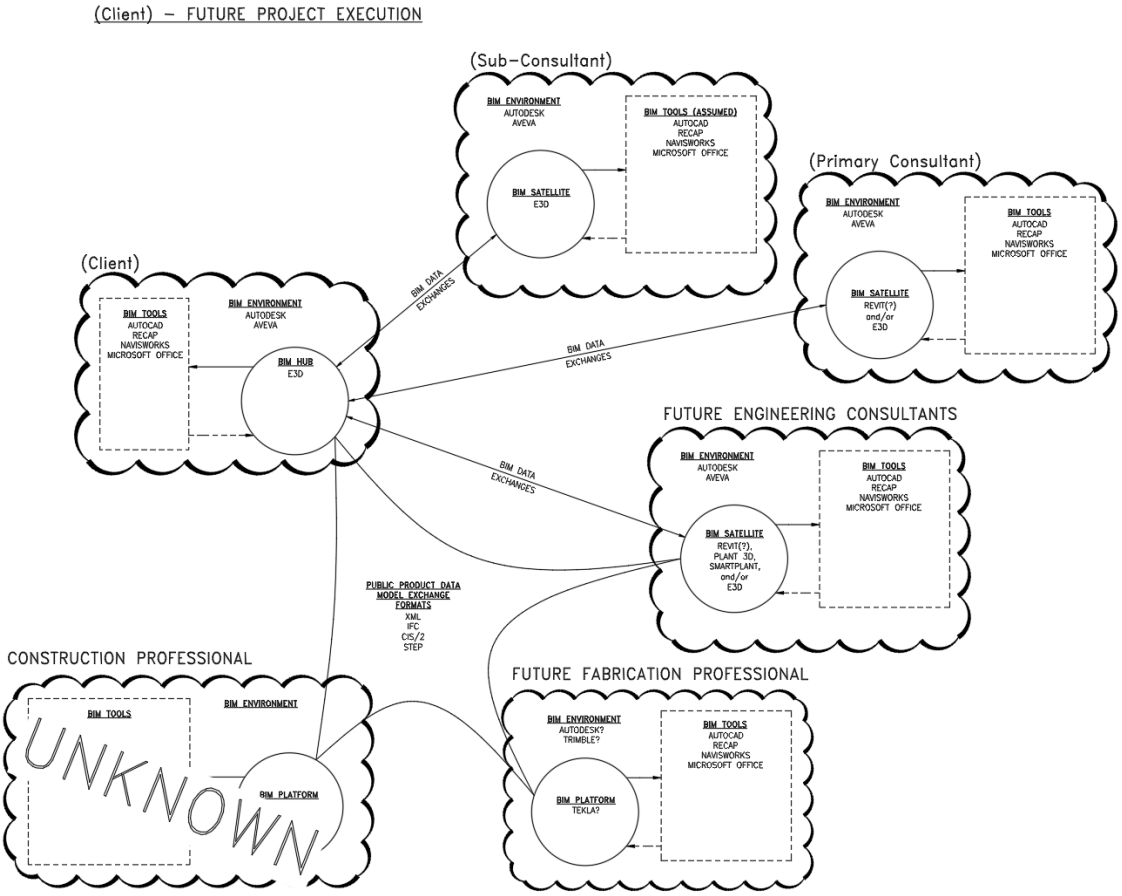
Here's an example of a project that utilizes BIM 360 for a model-server based BIM data exchange.



Here’s another example with a project that is being executed using Aveva’s E3D in a Hub and Satellite project arrangement.

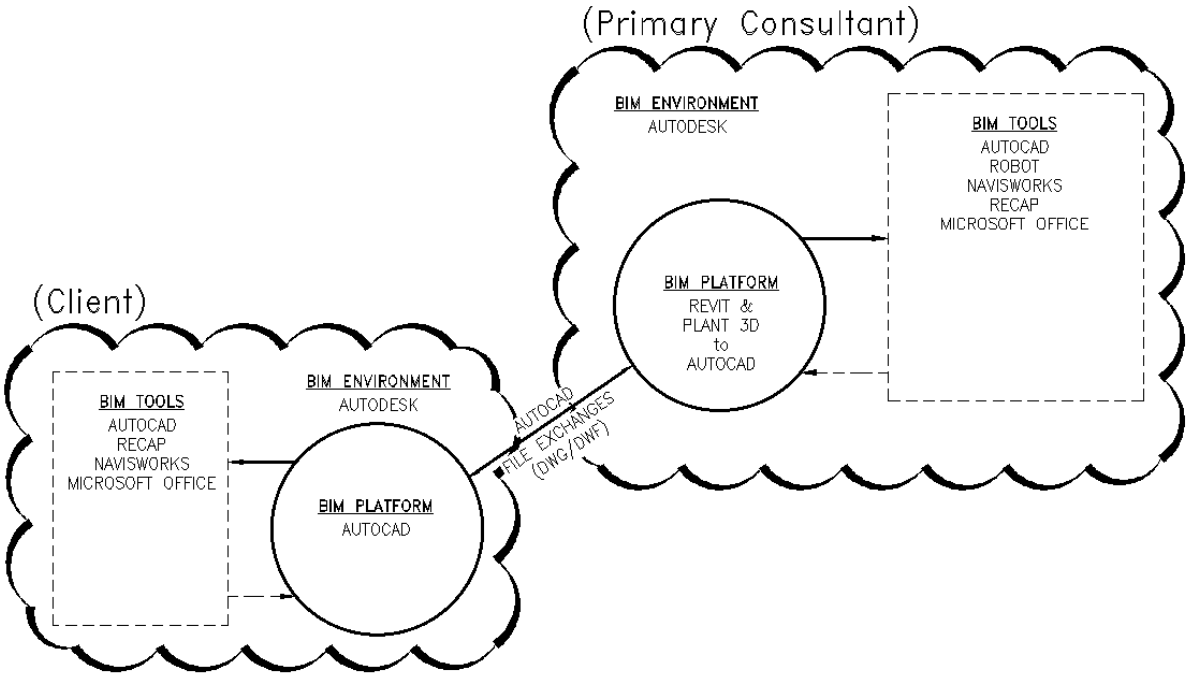


And, finally, yet another arrangement with a Aveva E3D Hub and Satellite set up that plans for future project executions.



The BIM Interoperability Framework combined with identified BIM Uses will ensure that every project is a success and is utilizing the most advanced software available. So, let's apply this knowledge and create one for 100' cube project.

For this project, let's say that we are going to be working in a Design-Bid-Build situation and that we only need to interface with the client. Our client wants the building handed over in AutoCAD to be managed in .dwg file type for both the model and the drawings. What would this interoperability framework look like? This framework would likely look something like this:



Working in an Autodesk BIM Environment where the client and the engineering consultant are utilizing AutoCAD to create a *Direct Link* data exchange is a good first step to understanding your projects interoperability. From there, we could identify that the BIM Platforms will likely be Revit, Plant 3D & AutoCAD for structural, piping, and equipment, which will all be communicated in dwg format. Can you think of any issues that might come up when you utilize this exchange? Would you be able to create a .dwg export that would meet your client's expectations?

Of course, making an export to AutoCAD from Revit loses all the properties that are built into the members we create in Revit, but it allows for the design consultant to utilize the power of parametric modeling, cost estimation, and engineering analysis that are all built into the model. Unfortunately, this client won't get to take advantage of that data, but maybe they'll update their project execution expectations in the future 😊.

Step 3: Identify your Level of Detail (LOD) Standard

Level of Detail (LOD) has been a topic of debate in the local industry for a number of years. It's a standard that makes sense immediately when is explained to the team, but it is an intimidating topic to have to formally communicate and dictate to the project team.

If you look up examples on the internet for how to create an LOD standard, many times the team will be forwarded to highly detailed spreadsheets and documents that can instantly turn the team off from wanting to create this standard. One way to communicate this information is to simply state that the team "shouldn't over detail items", but this rarely gets communicated correctly and is almost impossible to communicate once a project team grows.

One way that I've found to create simple and accurate LOD's for a project is to create a section in the BIM Execution Plan that is dedicated to the LOD Standard, providing images and some simple statements, like "CISC structural steel sizes" or "Grating floors modelled as a panel", are an easy to deliver and interpret method for communicating model information. An example of this is shown in Figure 20.

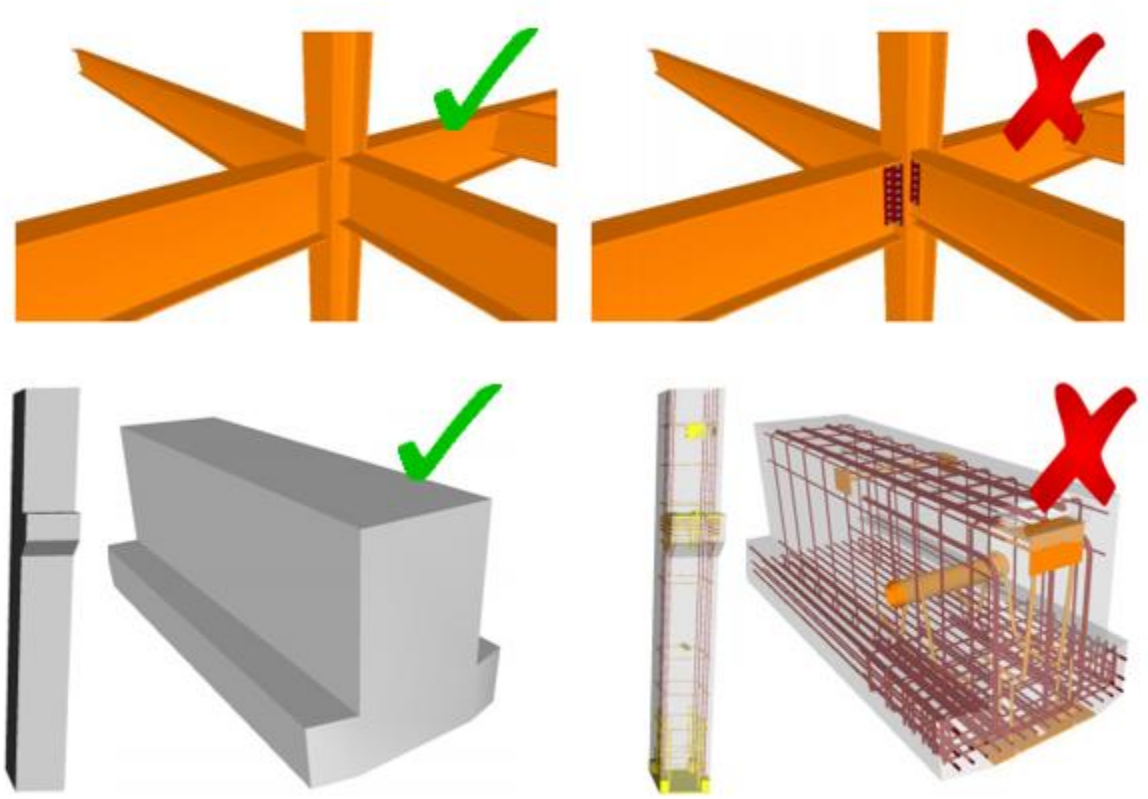


Figure 20 - Examples of a simple LOD Standard - Adapted from https://bimforum.org/lod/

The images here are taken from the BIM Forum LOD Specification, a free specification found at https://bimforum.org/lod/, which continually proves to be an invaluable source for communicating project information that can be shared to all project stakeholders. Establishing this early on a project will ensure project alignment and allow the project model to scale appropriately.

Is that it? Do we have our BIM Execution Plan?

Well, in essence, yes! Of course, there is more material to consider here, but this process can help to alleviate one of the most difficult parts of creating the BIM Execution Plan, solving the project interoperability.

If this is something you'd like to learn more about, there is a vast body of knowledge on the internet on this topic, but books like the *BIM Handbook* and *BIM and Construction Management* are great reads for anyone looking to gain quick and useable knowledge in the BIM space.

Using Revit for Industrial Projects

Now that we've identified how we are going to achieve are BIM uses for the project, lets dig in to the software that we'll use for executing the structural work: Revit.

Revit is a relatively easy to learn software with well-designed and intuitive menus. I say relatively, as training can allow for designers to gain fundamentals and some added expert knowledge, but it is not unusual for designers to learn everything they need to know from one or two Revit power users in the office. On the contrary, training staff to use other software providers that are more associated to an industrial industry is often a requirement for project execution, and it comes with an associated price tag.

Revit Weaknesses

Before we dig into the software, let's take a moment to understand some limitations.

The one thing I will say, is that Revit is a very CPU and Graphics heavy software. As mentioned in the BIM Handbook, "Revit is an in-memory system that slows down significantly for projects larger than about 100 to 300MB in case of Revit 2018 when the memory size is 4gb…Lacking object-level timestamps, Revit does not yet provide needed support for full object management in a BIM environment.".

Although Revit doesn't have this level of stamping on objects, it is still possible to organize object information using Revit's schedule functionality, so really the loss here is time-stamping functionality and its susceptibility to overloading computing power. Time-stamping is a very valuable feature, so it is worth considering; but, the computing power issue is perhaps the greatest hindrance of the software. Luckily for us, there is a way to overcome this.

Revit Capabilities

First off, Yes, Revit can be used for industrial engineering projects. This has been a personal battle for me with the local industry. The unfortunate reality is, when you conduct a google search on Revit, many of the projects and case-studies provided are associated with commercial and institutional spaces. This is an unfortunate representation of the software, as it can really be used for much more than just those use cases. Where the commercial and institutional environments overlap with the Heavy Industrial and Mining world is in Buildings and in BIM.

Revit is a software that enables BIM users to utilize a highly scalable BIM Platform or Tool. Revit can be used as a platform for the entire project, but it can also be used as a powerful tool when a different BIM platform is going to be used. Small projects can be executed quickly with a well set up project template, and large projects can be set up using worksharing and worksets that allow for large-scale buildings and sites to be built and managed.

Revit connects well with other software pieces in the Autodesk suite of software, allowing users to choose the software that makes the most sense for their project execution. Do you want to model pipe in Revit, or do you have Plant 3D users that are comfortable in that environment? Use Plant 3D and link the two models together! Do you want to create steel details in Revit, or would you rather detail in AutoCAD? Use AutoCAD and link your details into Revit! Want to create fabrication level detailing for your structure? Use Advance Steel and import your model back in to Revit! This is perhaps Revit's greatest perk in the Autodesk collection, and it's what makes this software collection so robust.

Understanding the relationship of each software piece in the AEC Collection is key to being able to execute projects well and knowing when and where to use Revit is the key to being able to execute projects in the heavy industrial and mining space, as well as other industries as well.

So, lets take a moment to go back to our 100' cube example again. If you were to create a structural model for our project using Revit with out of the box features, creating a structural steel model for project layout, as shown in Figure 21, can happen very quickly. A model like this can be created in about 10 minutes, is about 1mb in file size, allows for the creation of 2D parametric drawings instantly, links well with AutoCAD, can create parametric schedules and MTO's, as shown in Figure 22, can link to Navisworks for design reviews, can be connected with Robot for structural analysis, can customized to provide custom properties for creating custom asset management systems… The list really goes on.

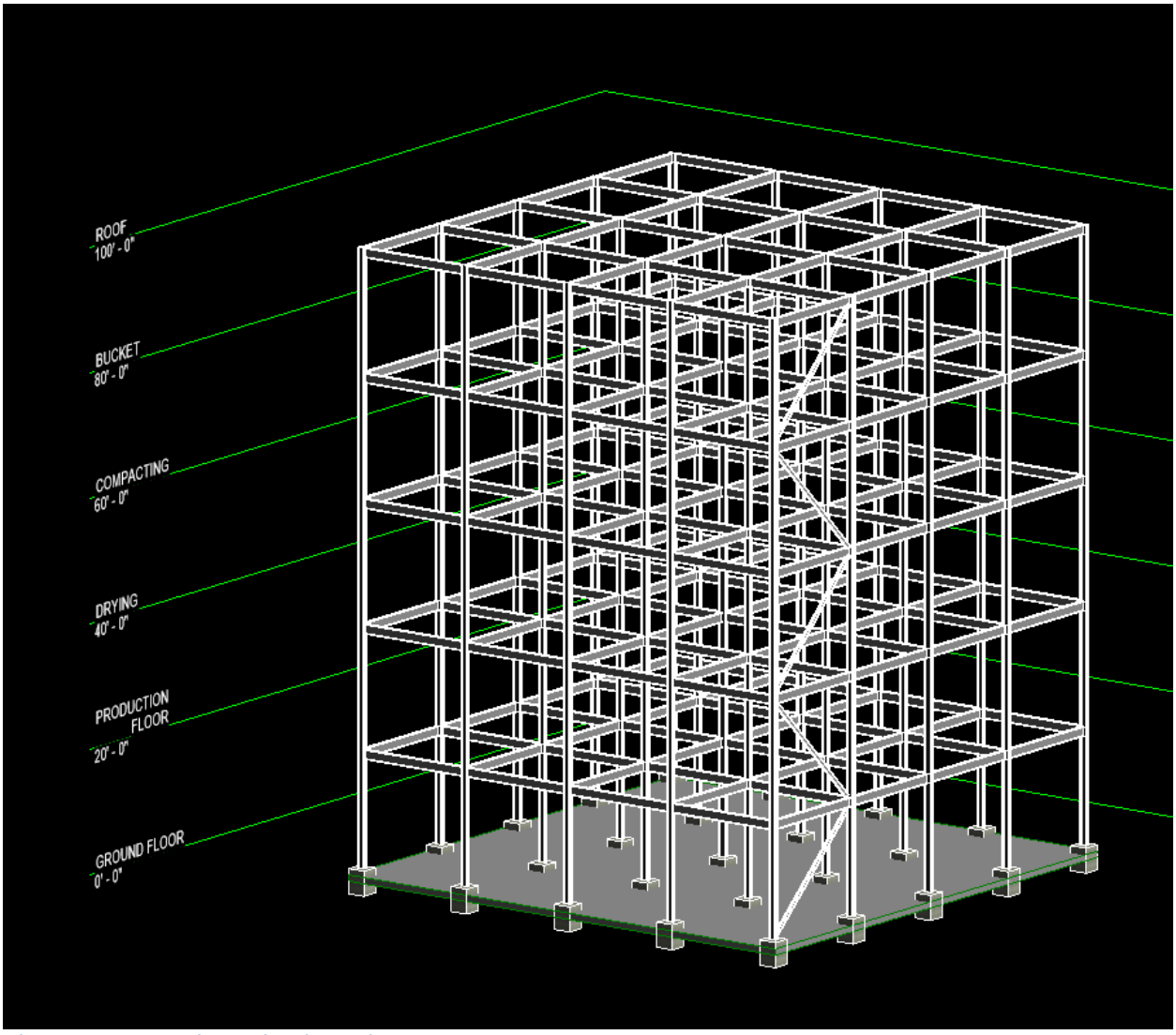


Figure 21 - 100' Cube Project in Revit

With all these features, Revit truly is a powerful software piece that can and should be used by design professionals. There is also substantial built in equipment, piping, and HVAC capabilities, connections with Inventor for equipment design, connections to Advance steel for

steel fabrication design. Given these capabilities, lets take a moment to try and understand the software's perceived weakness, larger project models.

Structural Framing Schedule

<Structural Framing Schedule>

A	B	C
Family and Type	Length	Reference Level
Beam-Steel-AISC-	20' - 0"	PRODUCTION FLO
Beam-Steel-AISC-	20' - 0"	PRODUCTION FLO
Beam-Steel-AISC-	20' - 0"	PRODUCTION FLO
Beam-Steel-AISC-	20' - 0"	PRODUCTION FLO
Beam-Steel-AISC-	20' - 0"	PRODUCTION FLO
Beam-Steel-AISC-	20' - 0"	PRODUCTION FLO
Beam-Steel-AISC-	20' - 0"	PRODUCTION FLO
Beam-Steel-AISC-	20' - 0"	PRODUCTION FLO
Beam-Steel-AISC-	20' - 0"	PRODUCTION FLO
Beam-Steel-AISC-	20' - 0"	PRODUCTION FLO
Beam-Steel-AISC-	20' - 0"	PRODUCTION FLO
Beam-Steel-AISC-	20' - 0"	PRODUCTION FLO
Beam-Steel-AISC-	20' - 0"	PRODUCTION FLO
Beam-Steel-AISC-	20' - 0"	PRODUCTION FLO
Beam-Steel-AISC-	20' - 0"	PRODUCTION FLO
Beam-Steel-AISC-	20' - 0"	PRODUCTION FLO
Beam-Steel-AISC-	20' - 0"	PRODUCTION FLO
Beam-Steel-AISC-	20' - 0"	PRODUCTION FLO
Beam-Steel-AISC-	20' - 0"	PRODUCTION FLO
Beam-Steel-AISC-	20' - 0"	PRODUCTION FLO
Beam-Steel-AISC-	20' - 0"	PRODUCTION FLO
Beam-Steel-AISC-	20' - 0"	PRODUCTION FLO
Beam-Steel-AISC-	20' - 0"	PRODUCTION FLO
Beam-Steel-AISC-	20' - 0"	PRODUCTION FLO

Figure 22 - Revit Parametric Structural Framing Schedule

Large Project Models and Worksharing

As mentioned previously, large project models can be the Achilles heel of Revit based project models, but, as has been proven time and time again, they are very much possible. Creating a large project model is possible through Revit's collaboration functionality known as Worksharing, and, once worksharing is enabled, through the granularity of model creation known as Worksets.

Worksharing is the way that you can scale your project model up for large project teams. When working on a large project model, creating many worksets allows for the building to be separated in a way that condenses the model into workable chunks that prevent Revit from maxing out its computing power limitations. Separating the model by a variety of different areas is a powerful method for allowing team members to control the amount of information that is brought into the model. To add another layer of separation and control, separate Revit files can also be made to create completely different areas of a structure with their own list of Worksets associated with them. These models can be linked together in Revit, or in Navisworks for viewing.

For example, lets take another look back at our 100' cube structure. Lets add on an expansion and separate each floor by a workset, as shown in Figure 23. This structure is relatively small, so creating a separate model file is not required. To create separate areas for the building model, the expansion has been separated to its own work set, whereas the floors and columns

have all been separated for their respective worksets. As the model becomes more detailed with the addition of infill steel, equipment supports, bracing, girts, and other model information, these worksets can be managed and controlled if file size becomes an issue.

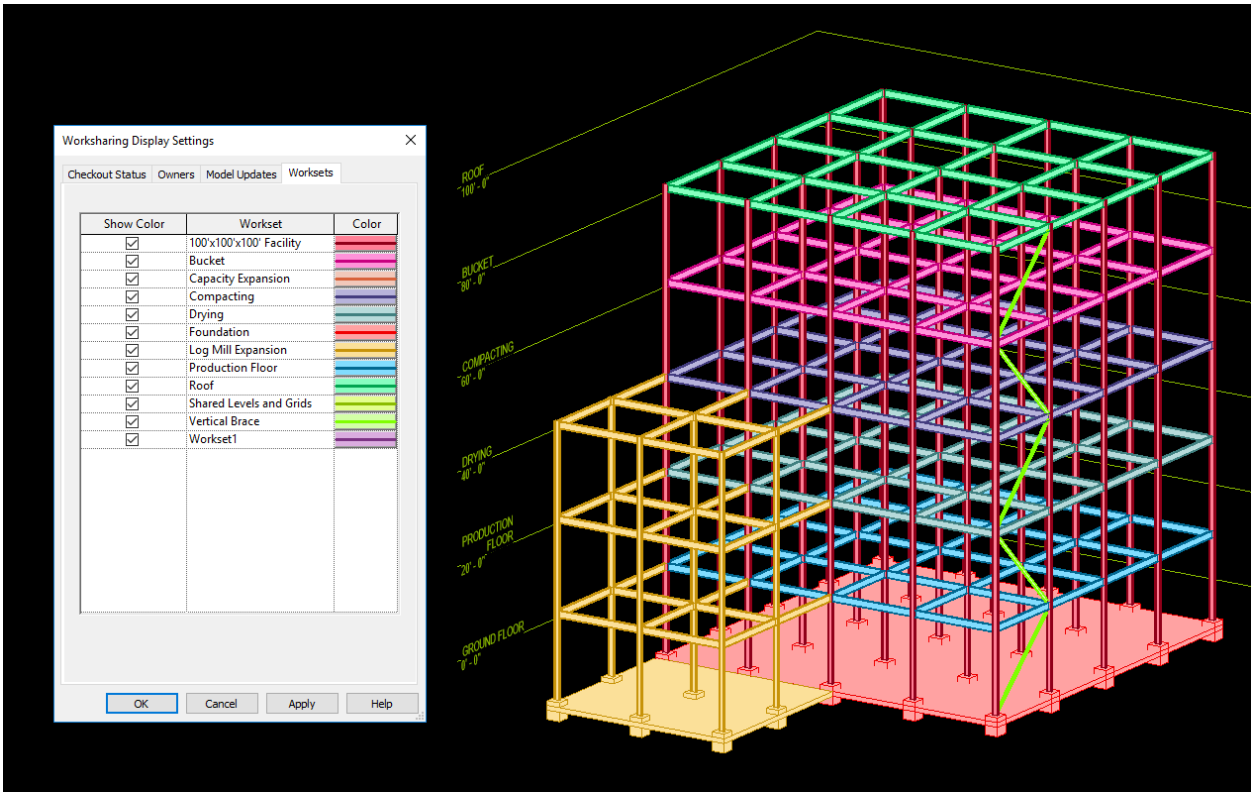


Figure 23 - The 100' Cube Project with Workset Separations shown using the Worksets Display Filter

One last item to mention, your team should resist the urge to use Worksets in the same way that AutoCAD uses Layers. I, myself, made this mistake early on when I first started using the software, and changing this process only becomes more challenging the more that it infuses itself in your standards and procedures. Worksets are best used when they are used for separating project areas, scope, and linked project information. Using this tool in this way is how you can build a robust BIM system using Revit and the rest of the AEC Collections BIM Tools.

Revit as a BIM Tool

Revit does not always need to be your BIM Platform. Using Revit as a BIM Platform utilizes some of the best and most capable features of the software, but that doesn't mean that it can only be used in that way. Utilizing Revit as a BIM Tool can be very powerful for projects where the client expects the deliverables all be provided in AutoCAD at the end.

Utilizing Revit as a BIM Tool is many times the first step to gaining traction and experience using the software. Many companies find Revit to be a daunting software to understand and rollout with their staff, but they understand the benefits that software can provide. Understanding and utilizing all the features may not be necessary or understood by everyone on the project team immediately but having a champion who chases these features can be all you need to get your team rolling in the direction of utilizing BIM. You don't' necessarily need a change or technology manager to see these changes, rather if you have enough time and

strong leadership, your team can adopt Revit and use BIM through incremental innovation. In my opinion, this speaks numbers on the quality of software that has been provided in Revit and its surrounding Autodesk pieces.

All it takes is one BIM Use to be used successfully on your next project for your team to begin adapting and implementing workflows that will eventually grow them into a cutting edge BIM company.

Talk about future

Recognizing BIM as a Technology

A change is occurring. Moving from the mentality of 3D modeling as a project solution towards BIM as a technology and project science is coming. I believe that BIM will be treated much like Project Management in the future, that is to say that it will be treated as a science with a very well thought out of body of knowledge to back it up. Our industry is working on developing new and innovative methods for executing work, and BIM is effectively providing our professionals with a widely understood language for being able to document and share information.

Some of the alternative BIM Platforms out there, such as Bentley Autoplant and Aveva E3D are successfully providing exceptionally BIM platforms that should always be considered, but identifying when and how these pieces of the technological puzzle are implemented is truly the key to being able to successfully solve the BIM interoperability challenge that we have all been faced with. I believe that our building professionals and our technology developers are only just breaking the surface of what is the complete potential of our industry.

Cloud based BIM Communication

Interoperability frameworks are a requirement for projects in today's project environment, but, in the not so far off future, projects will be executed more and more in cloud-based project environments. Our industry is on the verge of flicking the switch and executing projects in this way, and it's very exciting for myself and other professionals in this industry to be a part of. Some of the ways our industry has been innovating in designing and managing facilities will continue to put our professionals at the forefront of the industry.

An Industry of Continued Innovation

Beyond the big players in our province, like Nutrien, K+S, and Mosaic, there are several other startups, like Gensource Potash Corp, Western Potash Corp, and YanCoal, that are challenging the industry to utilize BIM Technology in new and innovative ways. These companies are establishing themselves in an industry where they can utilize the hard work and success acquired by our professionals during the Potash Boom, meaning that they will be able to use some of the most advanced technology developments in the world. Keep an eye on these companies and their surrounding service providers; they're all doing great things.

The unfortunate reality of working in an industry where change is many times slow and innovation happens in very steep and aggressive change curves is that, the adoption of new technologies and innovation cultures are typically difficult to establish and sustain. With this, historically it has been a challenge for me to communicate how and why BIM can be used on projects in our environment, especially when discussing BIM with clients. However, and this is a big however, the industry is beginning to change!

Many of the professionals that have worked through the ups and downs of the economy are beginning to see that there are better ways to execute projects and adopting a technology focused innovation mentality. This is especially true for the professionals that have worked in the industry through the Potash boom and continued working through the decline in the economy. As these professionals disperse through the industry and begin to be established in a variety of new roles, from Project Management and Discipline Managers, to Technology Managers and Design Leads, BIM is beginning to gain some real traction in the industry.

New occupations are beginning to arise, and the need for less of a dedicated CAD Management position is moving more towards BIM specialist and coordinator positions that work in a flatter design management structure. Everyone on the design team, young and old, is learning how to utilize BIM in their own way, and it's completely revolutionizing our industry.

Conclusion

So, that's it. Our industry has come a long way during my time within it, but it seems like there is so much more to solve. These are just some of the problems that I've had the opportunity to explore and solve in this industry, and, thankfully, there is no signs of this slowing down.

The next time you think about design and engineering in mining, think about this: The mining industry is one full of large organizations and small organizations, it is full of big tech and small tech, it is full of big innovations and small innovations, we can make changes immediately and quickly in booming times, and we can become rock solid in our efficiency during slow times, and it is this that makes or industry so important for the rest of the AEC world. It is my belief that this is what makes Saskatchewan's mining, engineering, and construction professionals world class technological innovators that everyone should know about.