



**BUILDING INFORMATION MODELING
FINAL REPORT: CASE STUDY**



Glenmore Landfill Administration Building, Revit Model, CEI Architecture

Prepared by:
Douglas MacLeod
with Trevor Butler & Scott Chatterton
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2. OVERVIEW

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Project Summary

This project used Digital Technology Adoption Pilot Program (DTAPP) funding from the National Research Council (NRC) to work with small and medium sized enterprises in the Architecture Engineering and Construction Industry (AEC) to enhance productivity through the training and deployment of Building Information Modeling (BIM). This case study was produced as part of project to illustrate the real world application of this technology. Specifically, it examines how BIM was used during the design and construction of the Glenmore Landfill Administration Building (or GLAB) in Kelowna, British Columbia designed by CEI Architecture.

Background

Building Information Modeling is a new approach to Computer Aided Design (CAD) and represents a more data-driven approach to design. Using BIM, a database (or model) is created to which more and more information is added as the design of the building progresses. From this database, it is possible to automatically generate all the necessary drawings and schedules necessary to construct the building. This same information can also be used by facilities managers after the building is in use to manage it effectively.

By using a single source of information for all phases of the process, there are increases in quality and reductions in time – particularly in terms of identifying or correcting mistakes. It has been estimated that BIM can increase productivity from 20 to 50%.

Purpose and Intent

The intent of this case study is to provide an in-depth analysis and assessment of Building Information Modeling (BIM) technologies in improving the productivity of building design and construction.

As noted, the vehicle for this analysis is a case study of the Glenmore Landfill Operations Building currently under construction in Kelowna, British Columbia. This study is intended to complement the productivity studies that have been conducted with the other Small and Medium-Sized Enterprises (SME's) that are also participating in the project.

While this case study focused on the productivity improvements to be gained through the use of BIM technologies, it also examined:

- The effects of using BIM across the entire design and construction team
- The other benefits (such as improved performance and enhanced sustainability) of using BIM in addition to productivity

This case study is also intended to improve understanding of the role that BIM may play in the design and construction process through a case study approach

Because the building is currently under construction it has provided a unique opportunity to examine the role of BIM during the construction process.

3. THE GLENMORE LANDFILL ADMINISTRATION BUILDING

[The information in this section comes from CEI's Fact Sheet on the building]

Client: City of Kelowna

Gross area: 615 m² (6620 sf)

Project Cost: \$1.99 million

Completion: December 2013

CEI Architecture's involvement with the City of Kelowna's Glenmore Landfill Administration building began in 2010 with the preparation of a full schematic design report, including programming and schematic design services. CEI's involvement is now continuing with the detailed design and construction of the project. The building is targeted for completion in December 2013.

The Landfill Administration Building has two primary functions. Landfill site staff have a dirty and physically arduous job. On the lower level they are provided full change rooms and facilities in accordance with best practices for the twenty first century. On the upper floor are offices for administration staff and a training suite for all staff, and potentially from other sites.

A visitor component will provide outreach to educate school groups and the general public on the work undertaken at the landfill site, and illustrate the benefits of recycling both on the global scale environmentally, and to the local community financially.

The design of the project responds to the City of Kelowna Policy 352 – Sustainable Municipal Infrastructure, which requires the City to build infrastructure that achieves target results across a slate of environmental, economic, financial, social and cultural indicators to achieve a sustainable and creative city. To achieve this goal, we applied a multiple bottom line analysis that included a large number of factors such as climate change; ecological footprint; watershed protection; financial sustainability and built value; innovation and design quality; use of wood; incorporation of innovative materials, recycling and reclamation; life cycle cost; and capital reserves.

The Glenmore Landfill Administration Building seeks to demonstrate how a modern office environment can successfully function using significantly less energy, exploiting alternate fuels sources such as landfill gas, and elegantly incorporating a wide range of recycled materials—all within a constrained conventional budget.

Sustainability

The design aims to reduce the energy use of the building by more than 40 percent over current standard building practices, and will be constructed to minimize impact on the local ecology. By adopting conservation and 'low tech' passive capture solutions, the building will greatly reduce overall energy, water and resources demands.

Through the use of composting toilets and diverting all grey water back to the landfill to boost methane production the building the building avoids any discharge to the municipal sewer system. This is the first use of composting toilets in the Okanagan Valley.

By following regenerative principles, such as methane gas generated from the landfill as the fuel source, and utilizing materials reclaimed from landfill, the scheme will become a truly place-based solution.

Building Description

The Glenmore Landfill Administration Building is a conventional wood-frame building designed to house the administrative and operational offices of the Glenmore Landfill. It is a two-storey structure with grade level entries to each storey.



Figure 1: Lower Level, GLAB, Revit Model (CEI Architecture)

The Lower Level includes

- Change rooms and showers for outdoor workers
- First aid
- Landfill operations monitoring equipment storage and maintenance
- Site foreman office
- Crew marshaling area
- Mechanical room

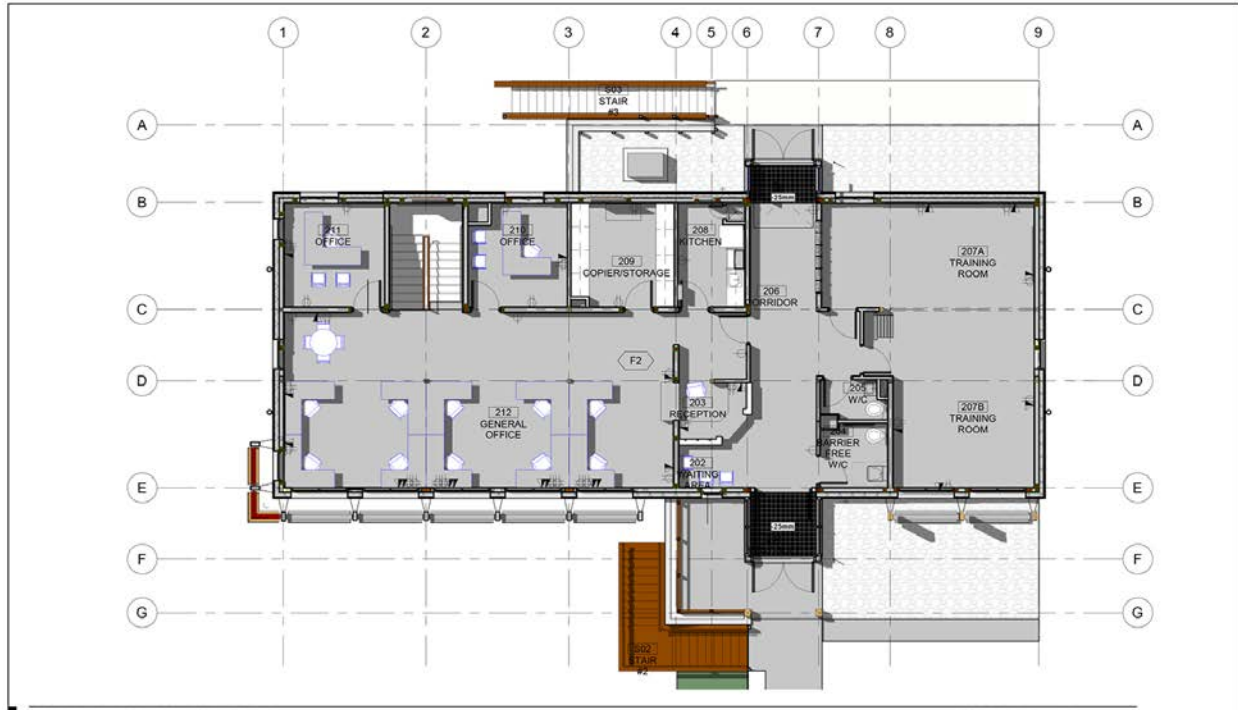


Figure 2: GLAB Upper Level, Revit Model (CEI Architecture)

The Upper Level includes:

- Workstations for administrative and logistics staff
- Public Reception
- Small Meeting/Training Room

Project Team

For CEI Architecture:

Tim McLennan PIC

Robert Parlane, Project Manager and Lead Designer

Myles Hogan, Contract Administrator and Site Inspector

Richard Bolus, Architect of Record

Structural engineer - Bush Bohlman and Partners

Mechanical & electrical engineer – Cobalt Engineering

Civil engineer and Surveyor - MMM Group

Cost Consultant - SSA Quantity Surveyors Ltd.

Landscape Architect - Site360 Consulting Inc. (MMM Group)

Geotechnical Engineers - Interior Testing Services

4. THE PROCESS

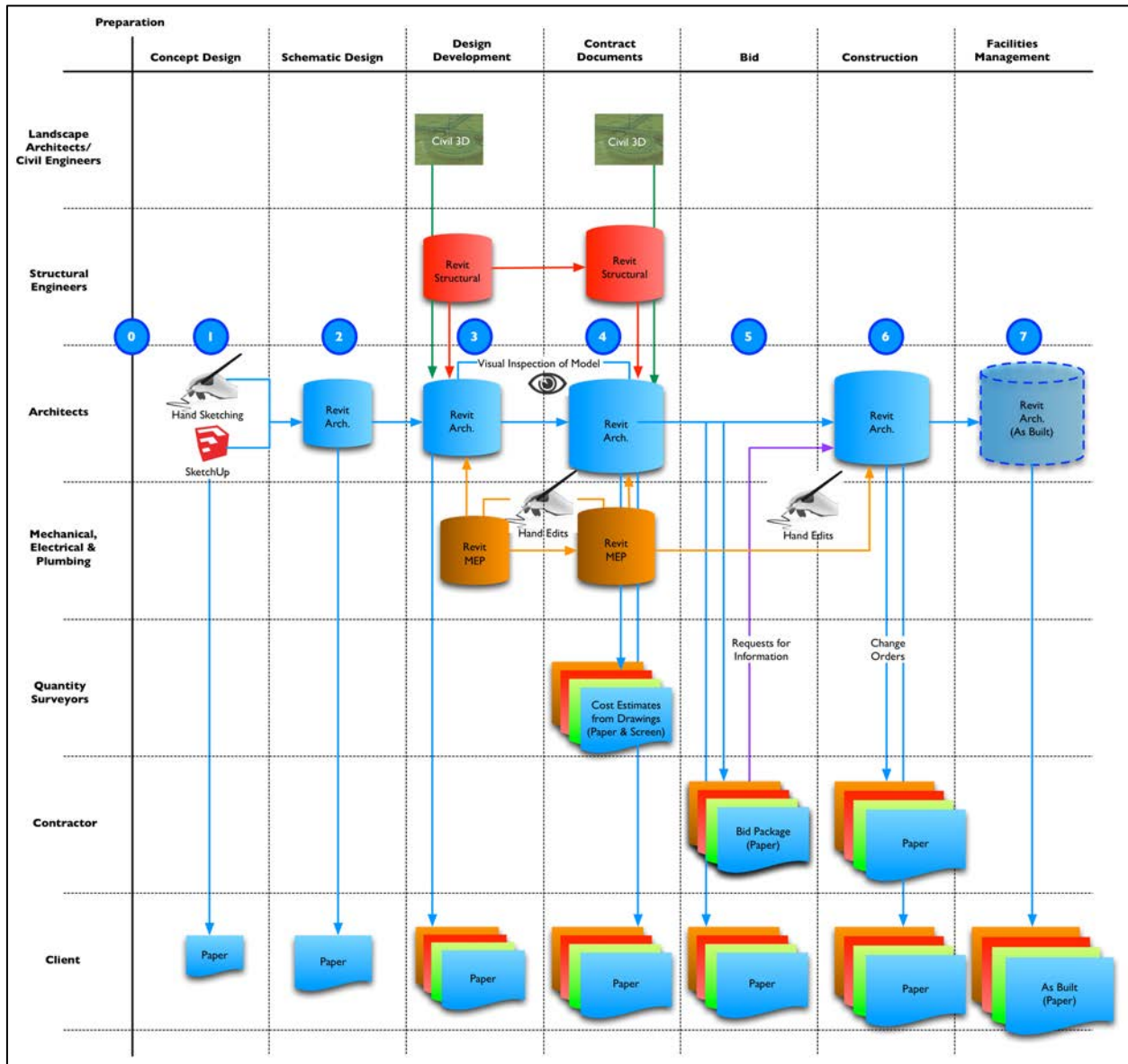


Figure 3: Flow of Information in BIM Process

As noted in Figure 3, the design and construction of this project proceeded through 8 distinct phases:

1. Phase 0 – Preparation and Setup
2. Phase 1 – Concept Design
3. Phase 2 – Schematic Design
4. Phase 3 – Design Development
5. Phase 4 – Contract Documents
6. Phase 5 – Bid and Tender
7. Phase 6 – Construction
8. Phase 7 – Facilities Management

This section examines how Building Information Modeling was used in each phase of the work.

Phase 0 – Preparation and Setup

The preparation and setup of a BIM project is arguably the most important stage of a successful project. Because BIM is a new digital technology that is not yet used throughout the AEC (Architecture, Engineering and Construction) industry, it is important that all consultants in the project are aware of its use. BIM is not a process that can be added to the project midway through its execution. In addition, some consultants, as it was in this case, may indicate that they cannot use BIM on a project.

To aid in the process, CEI Architecture has developed two documents:

1. Building Information Modeling Pursuit Strategy – to assist in securing a building project
2. Building Information Modeling Coordination Strategy – to assist in the design and construction project

Both documents are very similar. Their purpose is to:

- Clarify roles and responsibilities and collaboration and coordination techniques
- Establish protocols, timelines and model standards
- Streamline design and development of the model
- Set levels of detail

Levels of Development

The idea of levels of development is a critical part of the model. Level of Development (LOD) is a 5-point scale developed by the American Institute of Architects (AIA) to classify the degree to which BIM is being used in a project

These levels are described in the table below.

| LEVELS OF DEVELOPMENT | |
|-----------------------|--|
| Level 100 | Overall building massing indicative of area, height, volume, location, and orientation may be modeled in three dimensions or represented by other data. |
| Level 200 | Model Elements are modeled as generalized systems or assemblies with approximate quantities, size, shape, location, and orientation. Non-geometric information may also be attached to Model Elements. |
| Level 300 | Model Elements are modeled as specific assemblies accurate in terms of quantity, size, shape, location, and orientation. Non-geometric information may also be attached to Model Elements. |
| Level 400 | Model Elements are modeled as specific assemblies that are accurate in terms of size, shape, location, quantity, and orientation with complete fabrication, assembly, and detailing information. Non-geometric information may also be attached to Model Elements. |
| Level 500 | Model Elements are modeled as constructed assemblies actual and accurate in terms of size, shape, location, quantity, and orientation. Non-geometric information may also be attached to modeled elements. |

Table 1: Levels of Development (AIA, 2008)

In the strategy documents developed by CEI, the Pursuit Strategy specifies an across-the-board Level 200 for all consultants. The Coordination Strategy, however, uses a matrix in which one dimension represents the disciplines involved, such as Civil Engineering, and the other various elements of the building such as the substructure and shell. Each cell in the matrix could have a different level of detail.

Software Platform

As will become readily apparent in subsequent phases of the work, there is not a single software package that fulfills all of the requirements of all of the consultants on the project.

For this reason, both strategy documents specify the software platforms to be used on the project. For this project, the platforms were specified as:

Autodesk Revit Platforms

- Autodesk Revit Architecture 2013
- Autodesk Revit Structure 2013
- Autodesk Revit MEP 2013
- Revit 2013

Autodesk AutoCAD Platforms

- Autodesk Civil 3D 2013
- Autodesk AutoCAD Architecture 2013

Collaboration Platforms

- Autodesk Design Review 2013
- Autodesk Navisworks 2013

It is noted that all of these products are produced by Autodesk which dominates the computer-aided design (CAD) market. It is also noted that only the Revit product line would be considered true BIM software.

Phase 1 – Concept Design

Concept Design is the exploratory phase of the work where many alternatives are quickly explored and often discarded. Typically only the architects are involved at this early stage.

For the GLAB, BIM software was not used during this phase. The architectural community is divided regarding the usefulness of BIM during this phase. Some feel that the benefits of BIM cannot be fully realized if BIM is not used through the entire process. Others feel that BIM demands too much detail at this stage and its interface is not compatible with “quick and dirty” explorations.

In this case, the architects used hand-drawings and the free 3D modeler SketchUp to develop concept designs which were shared with the client in paper form. This highlights an interesting development in the AEC industry where the architects and engineers who design the building are not “hands on” with the software, but rather must hand off their design to CAD operators.

Phase 2 – Schematic Design

The design is further developed during schematic design. In the traditional process, floor plans and elevations would be developed and shared with the client. In contrast, the BIM process involves

building a 3D model which typically has a greater degree of detail (and takes longer to develop) than the traditional method.

For the GLAB, the concepts developed in the previous phase were now transferred to Revit Architecture 2013 (the BIM platform). This involved rebuilding the entire model since there is no transferability between SketchUp and Revit.

Again, paper drawings were shared with the client.

Phase 3 – Design Development

During Design Development, additional consultants such as the mechanical, electrical, plumbing, structural and civil engineers become involved and the building becomes more and more detailed as these systems are added. Again, a BIM approach involves a greater degree of detail than the traditional approach.

For the GLAB, the mechanical and electrical engineers (a single company) used Revit MEP (Mechanical Electrical and Plumbing) 2013 and the structural engineers used Revit Structure 2013. The architects coordinated all the models by regularly scheduled updates on a weekly basis and the architectural model continued to grow.

The civil engineers and landscape architects (also a single company) used Civil 3D for their work. The client received an increasingly detailed and complex paper set of drawings.

It is also noted that the architects would often use visual inspection of the model to check for coordination problems (such as when a mechanical duct would be inadvertently designed to run through a structural member). This was because the automated collision detection software in Revit often identifies hundreds of false collisions. The mechanical engineers noted that they often used hand drawings to communicate designs and design changes with the BIM operators.

Again model was regularly updated on a weekly basis and the client received a paper copy.

Phase 4 – Contract Documents

This is the last phase of the design process and traditionally involves the development of the detailed drawings that describe all of the conditions to be found in the building. This is where BIM should show its real advantage since if the model has been developed properly, these details can be automatically generated from the model itself.

During this phase, quantity surveyors also estimate the cost of the building to see if it is on budget prior to contractors bidding on the work. The quantity surveyors on the GLAB did not use BIM software because the manner in which the Revit model stored information was not compatible with the way they worked. Instead, they used paper and screen images to create their cost estimates.

Phase 5 – Bid and Tender

During this phase various contractors examine the design and estimate how much it will cost to build the building. Typically the lowest bid wins the contract.

The GLAB followed the traditional process and sent each contractor a roll of drawings. The BIM model was not used by the contractors.

Often during this phase, contractors will request clarifications about the design in the form of Requests for Information. The architects issue these clarifications and in the case of the GLAB they also updated the model.

Phase 6 – Construction

Once the bid is awarded to a particular contractor, construction begins. No design is perfect so changes in form of Change Orders are often issued during construction. These are often very expensive.

If BIM has been used properly then these kinds of changes will be minimized - but not eliminated. For the GLAB, the architects, in concert with the client, issued the Change Orders and updated the model. If the change impacted the engineers, they would hand draw or use CAD to make their changes and send them to the architects to update the model. Paper was used to communicate with both the contractor and the client. The GLAB is currently under construction and should be completed by December of 2013.

Phase 7 – Facilities Management

Once the building is opened, it must be managed. This is referred to as facility management. By this point the architect will have a complete BIM model that represents the “As Built” condition which is invaluable in managing the building.

In the case of the GLAB, the client did not have the necessary in-house expertise to use Revit and therefore will not make use of the model.

5. ANALYSIS

While BIM was not used throughout the entire process for the GLAB, this project does provide a realistic look at the current use of BIM in the AEC Industry.

Benefits

Even at this early stage there are benefits to using BIM on a job such as the GLAB. These include:

1. Savings in time during contract administration due to a reduced number of Requests for Information and Change Orders
2. Savings in money due to a reduction in major mistakes. On a large project, catching even one major mistake before the bid period can save thousands of dollar and easily compensate for the cost of hardware, software and training.
3. Improvements in quality because design team members have a better understanding of the project.

Barriers to Utilization

At the same time, this case study also highlights that there are serious barriers to the wide scale acceptance of BIM:

1. The AEC Industry is conservative. It will take time before a major revolution such as BIM is universally accepted.
2. The price of the software (about \$6000 per seat) is high – particularly for small or one-person architecture firms.
3. There is a shortage of skilled BIM operators and many senior architects and engineers do not have the time or inclination to become adept with this new technology.
4. BIM disrupts the normal fee structure for a building. Fees are generally less at the start of a traditional project and increase as more detail is added to the design. BIM changes this kind of fee schedule. If the design team invests too much time at the start of a project, they lose money. One engineer estimated that it was 20% more costly to work on a BIM project than a traditional CAD project.

Measuring Productivity

Because a variety of different and non-BIM software packages were used on the project, it is impossible to say if the use of BIM improved productivity. Certainly, as noted above, some consultants felt it increased the cost of the project thereby lowering productivity. On the other, as another consultant mentioned, becoming adept with BIM today will mean, “Savings in the future.”

Commentary

Buildings are complex entities whose design and construction involves many different professions and trades. Over the course of centuries, each profession and trade has developed their own unique way of working. Architects have always presided over an uneasy coordination of disciplines and the traditional (and cumbersome) multi-step approach to design has evolved as a means of checking and rechecking the work. While the introduction of CAD was disruptive, it still maintained the traditional structure and schedule of a building project. CAD took an “electronic pencil” approach to design.

BIM requires rethinking the fundamentals of the design process. Far from being an electronic pencil, BIM is a database approach to design where graphic elements can take on a variety of non-visual properties such as insulation values, fire ratings and even warranties. This is a conceptual change as much as a technical one and one that also has financial implications

For example, proponents often mention that with BIM architects spend more time designing and less time drawing. This is, however, a double-edged sword. In the past, a designer could hand off a sketch to be drawn by a CAD operator, but now the designer must be actively engaged with the BIM model throughout the process. As one consultant noted, it is difficult to design and draw at the same time.

BIM holds the promise of revolutionizing the design, construction and operation of buildings but it also demands a degree of coordination in terms of working methods that is foreign to the industry. While Revit attempts to solve this problem with different packages for structural engineers, mechanical engineers and architects, quantity surveyors (to name just one) feel that the information is not presented in a manner that facilitates their job of cost estimating.

Even within a single discipline such as architecture, BIM is not ideally suited to all phases of the design. As was noted, some architects feel that BIM is too awkward to use in the early stages of the design. There are, however, two sides to this problem. On the one hand, Revit may need more concept tools, while on the other, designers may not have the skill sets to use that software effectively.

A number of architects and engineers have also commented that in some cases it is easier to create a two-dimensional drawing by hand or in a conventional CAD program than it is to create or change a BIM model. Such drawings, however, mean the BIM model is no longer up to date. One structural engineer has noted that it is much harder to make changes in BIM and this can have a very negative impact on their fees.

At the same time, while clients are increasingly demanding BIM on their projects, they may not have the capability to utilize the model effectively or at all. Moreover, even when they want a BIM project, they are reluctant to pay more for it.

Finally, there is a concern that one company, Autodesk, dominates the market and as Revit becomes the industry standard there will be little competition to lower or maintain the price of the software.

6. CONCLUSIONS AND RECOMMENDATIONS

As this case study illustrates, the AEC Industry has yet to realize the full potential of BIM. In the future, architects and engineers will be able to assemble entire designs from libraries of components. Each component will be an intelligent model which stores its own properties. Insulation, for example, will store its own R-values so that accurate energy analyses can be conducted. Cost estimating will be more accurate and automated because each component can go online and access its current pricing.

There is little doubt that BIM is the future of the AEC Industry but it will take some time before it is universally accepted – and to be effective it must be used by all members of the design and construction team.

For Small and Medium-sized Enterprises to survive (and even thrive) in this new world of design and construction, a number of recommendations can be made:

1. SME's should have access to ongoing, low priced training at various levels of expertise that could be provided by community colleges – as is happening.
2. SME's would be well-advised to create or actively participate in user groups and other communities of practice as a means of keeping up to date with the latest developments
3. On another level, BIM should be thought of as an open-source standard in which information could be easily moved between different software packages. For example, a HVAC (Heating Ventilation and Air Conditioning) unit created in ArchiCAD (a competitor to Revit) should be able to be dragged and dropped into a Revit model and still retain all its properties
4. Much as lamps and lighting fixtures undergo testing by a third party organization to verify their properties, the world of BIM needs a third party organization to independently verify the proposed performance of an HVAC unit if that data is included in the BIM model
5. Fee structures should be re-organized to reflect the changes that BIM brings to the design process.

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