

**WILL THE IMPLEMENTATION OF BUILDING INFORMATION
MODELLING BE ADVANTAGOUS TO THE SOUTH AFRICAN
CONSTRUCTION INDUSTRY?**

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Abstract:

Building Information Modelling (BIM) is the process of generating and managing building data during its life cycle. Over the past decade Building Information Modeling has been implemented in various countries, and is rapidly expanding in the construction industry. Countries that have taken the initiative to implement the system are already able to see the advantages the system offers. This research project focuses on the different BIM products available, the advantages and disadvantages of BIM and the implementation strategies of BIM in various countries. This is to see what BIM offers the market, and if it is necessary to implement this system in South Africa. It also tries to establish how this system should be implemented and when it should be implemented.

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Chapter 1- Introductory Chapter:

1.1 Overview of Topic:

“Building Information Modelling (BIM) is the process of generating and managing building data during its life cycle. Typically it uses three-dimensional, real-time, dynamic building modelling software to increase productivity in building design and construction. The process produces the Building Information Model (BIM), which encompasses building geometry, spatial relationships, geographic information, and quantities and properties of building components.”

[http://en.wikipedia.org/wiki/Building_Information_Modeling, (14 February 2010)]

The concept of building information modeling has grown substantially over last decades due to the rapid expansion of technology, especially the use of computers in everyday life. The processing power of computers has increased dramatically, and prices have dropped to such an extent that computers have become accessible to even the smallest of companies. The same is becoming a reality with the software market which is constantly expanding, and catering for new areas of design and management into its products. Technology has become one of the main contributors to the practice of lean construction. It is changing the way things are done in almost all aspects of a project. This includes feasibility, design, procurement, construction and maintenance over the life of the product. Contrary to popular believe that BIM is a completely new product on the market, the basic BIM products have been in existence for about 12 years. Products like AutoCAD, Revit Architecture, and Auto Cad Civil are the building blocks of BIM. These products started off as design aids, as to eliminate the tedious task of redwing drawings every time changes to the design are made which took up valuable time, and added considerable cost to project budgets. The reason for BIM receiving much attention of late is the

addition of new products, and the incorporation of these into one system. BIM has moved from simple 2D un-intelligent design and layout drawings to 5D modeling through the addition of Auto Desk Navis Works, and other Products. BIM moving into a 5D environment means it now incorporates the additional aspects of time, or 4D and cost which are the 5D component.

The Function and main advantage of BIM are as follows, BIM provides a platform in which the different parties of a construction project, including the client, the professional team and the contractor work together, using and having access to the same information in real time.

Instead of each party working separately on their section of the project, everyone is involved in the entire process. This entails the professional team, design team, contractors and employer giving input into the same collective database from the feasibility phase right through to practical completion and maintaining the building. Communication gaps are minimized, and the access to information is optimized, as a central system is used.

BIM, being an intelligent 5D tool can be used to locate flaws in the design, on site planning, for instance the erection of cranes and storage of material, and for identifying problems concerning time delays and costs.

Problems relating to the project can be identified at the early stages, and a combined effort can be made solve these problems.

BIM offers separate advantages to all parties using it.

The main focus will be on the advantages it provides to contractors.

Some of the advantages to contractors are as follows:

- Improved visualization
- Improved productivity due to easy retrieval of information
- Increased coordination of construction documents
- Embedding and linking of vital information such as vendors for specific materials, location of details and quantities required for estimation and tendering
- Increased speed of delivery
- Reduced costs

[http://en.wikipedia.org/wiki/Building_Information_Modeling, (14 February 2010)]

Having access to the BIM which usually links the parties through an ftp server, contractors can be involved in the project from an early stage. Having access to all the relevant information gives the contractor the ability to better plan and co-ordinate the project. This is an advantage when tendering, facilitating more exact tenders, and through out the construction process, as changes to drawings, documentation is made available in real time.

It also simplifies the process of getting sub contractors on board, to getting materials on site at suitable times, to keeping costs to a minimum.

Work space requirements and site layout can also be factored into the simulation. BIM programs provide the contractor with a complete bill of quantities, and errors due to lack of information and incorrect interpretation of the documentation are kept to a minimum.

Any changes to the project are immediately available to the contractor, and corrective action can be taken.

The next step or the future of BIM will be 6D - The aspect of Life Cycle Management (owner/FM).

There is however no products available at this stage with good BIM workflow yet.

BIM will have to be introduced into the South African market at some stage to be able to keep up with international innovation. This will however be a costly procedure, and will have to be backed by government either in the way of incentives, or slowly introducing it into the market as in other countries

1.2 Statement of main problem

1.2.1 Will the implementation of Building Information Modeling be advantageous to the South African Construction Industry?

As can be concluded from the above statements, an era of BIM has started in the global construction industry and will have to be introduced into the local construction industry to keep with the latest developments and stay competitive.

At this point in time South Africa has not embraced the change in the industry. This has various implications for companies which are looking to not only extend their reach into foreign markets, but also deliver a higher quality end product in the local industries. The building information system has implications not just for the contractor, but all professionals involved in the industry, as well as for the client. The focus will be on the extent of advantages and disadvantages of the system on the industry. Does the implementation of BIM offer a substantial advantage the construction compared to the cost of implementation?

1.3 Statement of sub problems

1.3.1 What are the different products available to the end users?

The decision on which product is to be used by a specific company is analyzed in this section. The four largest BIM developers are analyzed, according to the products they offer. The strengths of each product are highlighted as well as the support offered by the specific companies.

1.3.2 What are the benefits and advantages of implementing BIM in the local construction industry?

The advantages BIM offers to the different parties of a project at the various stages. The following stages of a project are looked at:

- Benefits at Planning
- Benefits at Design
- Benefits at Construction
- Benefits at Maintenance

The advantages to the end user that are looked at include the following:

- Improved visualization
- Improved productivity due to easy retrieval of information
- Increased coordination of construction documents
- Embedding and linking of vital information such as vendors for specific materials, location of details and quantities required for estimation and tendering
- Increased speed of delivery
- Reduced costs

1.3.3 What are the problems facing companies wanting to implement BIM?

As with any new product or development, there will be problems that companies will need to deal with in order to successfully implement the product. This chapter will be used to highlight the issues and try to resolve some.

What disadvantages will be experienced by the parties, referring to:

- Speed of BIM
- Economy of Scale
- Outsourcing BIM

1.3.4 How has BIM been implemented in other Countries?

BIM has already been implemented in various countries. This chapter will identify the processes and strategies used by the various countries for the implementation of BIM. Both the private and public sector will be involved in the implementation of BIM in a countries industry, and the function of each will need to be taken into account. The countries the will be looked at include the following:

Finland

Norway

Denmark

Singapore

The United States of America

1.4 Statement of the hypotheses:

It seems as though the South African construction industry is not willing to take the risk of being a forerunner in the times of building information modeling. This may end up being very costly, as playing the catching up

game might be the safer option, but it will put us at an even greater disadvantage as others will be far ahead of us in the years to come. Thus creating gaps that will be difficult if not impossible to close at a later stage.

1.4.1 What are the different products available to the end users?

There are several different companies marketing BIM products at this point in time. It would seem that companies become confused with which product to choose. The research will show what the strengths of each company are, which should simplify the choice between the different products.

1.4.2 What are the benefits and advantages of implementing BIM in the local construction industry?

The hypothesis for the advantages of implementing BIM into the local market is that it will have great advantages for companies willing to take the steps to implement it.

These would range from a decrease in labor required for a specific project to a better quality finish of the end product.

1.4.3 What are the problems facing companies wanting to implement BIM?

The disadvantages of implementing BIM is that a large initial capital outlay will be required which will be a burden to carry for the contractors taking the step to implement BIM.

Another big disadvantage is that many professions will become almost obsolete due to the technological advantages which will lead to job losses for certain individuals.

1.4.4 How has BIM been implemented in other Countries?

The hypothesis on how BIM has been implemented in other countries is that both the public and private sector will play a major role in the implementation of BIM in the industry.

The public sector will be mainly involved in the setting up of guidelines for the implementation of BIM and the requiring of companies to implement BIM on various projects.

The public sector will be responsible for the actual use of BIM on projects.

1.5 Research method

The data collection on BIM is to be achieved through studying studies done on BIM.

These will include studies done on the advantages, disadvantages of using building information models, and looking at models of implementing the system in countries that are now using this technology on construction projects.

As BIM is a new tool in the market, the studies will be obtained through Google scholar, the universities internet portal, and through web sites dedicated to BIM.

Furthermore the local Autodesk agents will be contacted, which is one of the companies offering BIM, and finding out how they intend on introducing BIM into the South African market.

Another source of information will be professionals directly involved in the implementation of BIM on a project in the USA. These will be contacted to receive feedback on the implementation of the system in a live setting.

Chapter 2- What are the different BIM products available to customers?

2.1 Choosing the correct software package

The concept of BIM is rapidly rising within the construction industry. Companies are constantly developing new software packages as well as upgrading existing ones. Choosing the correct BIM products leads to increased productivity and functionality. Companies that are on the verge of integrating BIM into its current working methodology are confused about what to choose and which software package will give them the best results. This is not only dependant on the product itself, but also on the services offered by the different companies, pertaining to training and after market service. At this stage, approximately half a dozen fully functional BIM tools are already available to choose from, and about the same amount of vendors. Companies are constantly marketing their next generation design tools, to become the leaders in the market. The following is a summary of the 4 largest competitors, and which of them large architectural firms have chosen for some of their projects.

2.2 Autodesk

Autodesk was founded in 1982 in the Mill Valley in California. The company focuses on 2D and 3D design software, and “has arguably become best-known due to its flagship computer-aided design software AutoCAD. In addition to AutoCAD, Autodesk develops Digital Prototyping solutions ^[2] to visualize, simulate, and analyze real-world performance using a digital model during the design process. The company also develops Building Information Modelling software to generate and manage building data using a three-dimensional building model.”

[\http://en.wikipedia.org/wiki/Autodesk, (28 September 2010)]

They are using their marketing power to launch their BIM platform solutions. The interesting part is that they are actually competing against themselves as they are offering two different BIM programs.

2.2.1 Autodesk Architecture 2008

“This is an updated version of a 7 year old program that used to be called Architectural Desktop (ADT). This program is based on AutoCAD, their original 2-D CAD product, and comprises of an object-based BIM solution. When working with Autodesk Architecture it exhibits the same feel as working in AutoCAD but you can utilize BIM functions on top of it.

It is a unidirectional multfile solution that saves the drawing files (DWG's) separately. Each file usually contains information about other particular parts, objects or components of a building, such as plans, walls and doors. These files are linked together by a so called xref function and the program's Project Navigator is a tool that can interact with these documents. Autodesk Architecture is unidirectional in a way that any modification to the model is changed in all other views but not all views can change the model. Usually the documents or drawings need to be saved and views refreshed to make them updated with the recent model modifications. Right now Autodesk Architecture (ADT) is the most distributed BIM software, largely coming down to the huge AutoCAD user base. It is a very sophisticated piece of software and a capable BIM solution, especially for those who are used to AutoCAD. In the hands of a user that is experienced, it becomes a very productive tool and is definitely capable of handling big projects.

In the construction document phase it comes in handy as the native DWG format is being used, so there are no complications when going into the 2-D detailing part. That is one of the major selling points for

Autodesk Architecture as it is excellent in producing these documents as the program consists of a very robust detail library.”

(Agustsson, G.I., 2007, Building Information Modelling and the impact on the building industry, pg 12)

1.2.2 Autodesk Revit

“In 2002 Autodesk purchased a company from Massachusetts, Revit Technology Corporation. This company developed 3D software for the mechanical design industry and used the same concepts to create a version for the AEC industry. This tool was Revit, and as Autodesk states, engineered solely for BIM purposes. Autodesk’s Phil Bernstein has often called Revit the future direction of AEC software. Autodesk has three different versions of the Revit software:

- Revit Architecture
- Revit Structure
- Revit MEP

After the launch of the 2008 version Autodesk decided to reveal Revit’s Application programming interface (API), which will further enhance development of third-party plug-ins for the program. This is very good for the users as more energy analysis, specification and scheduling programs can be used alongside Revit in the future. Revit has a rather easy learning curve which is very good for new users to get accustomed with BIM. The program itself is a bidirectional single-file solution, meaning that any change or modification to any object or document in the model is rectified and changed in all views and sheets at once. It seems that Revit is getting some attention from architecture firms as many are using the software to launch pilot projects to test BIM methodology. One of the world’s leading architecture, urban design and engineering firms, Skidmore Owings and Merrill LLP (SOM), are using Revit for their design of the Freedom Tower project in New York.

This 541 meter high building will be monumental as it will be the first construction made on the former World Trade Centre site. The elegant glass structure will have more than 790.000 square meters in total, and comprising of both commercial and public space like restaurants and observation decks. Everything in this new symbolic tower will be of the highest standard, ranging from design, safety, sustainability and quality. SOM decided to implement the Revit platform to their project as they wanted to minimize errors during construction. With Autodesk by their side as consultants they seem to have it all under control as it gets closer to the proposed completion year of 2011. The result of this project will be interesting to see as this enormous project will be a huge advertisement for Autodesk and the Revit Platform. At this stage Revit does not have a big user base mainly due to the short period has been on the market. Even though the program itself is very new it is already conceived as an excellent BIM solution and with Autodesk's marketing power it could end up being the industry favourite.

The one thing customers are not satisfied with is that Autodesk is offering two totally different solutions and seem to be favouring Revit at the cost of Autodesk Architecture (ADT). The transition from ADT to Revit that is clearly being suggested by Autodesk is not going to stop the development of ADT for at least 5 years in the opinion of the author. This comes down to the number of users ADT already has and the licensed customers do not necessarily have the funds and manpower to change one BIM platform to another, just because Autodesk is recommending it."

(Agustsson, G.I., 2007, Building Information Modelling and the impact on the building industry, pg 13)

2.3 Bentley

“Bentley Systems Incorporated provides software for the "Design, construction, and operation of the world's infrastructure". The company's software serves the building, plant, civil, and geospatial vertical markets in the areas of architecture, engineering, construction (AEC) and operations. Their software solutions are used to design, engineer, build and operate large constructed assets such as roadways, railways, bridges, buildings, industrial and power plants and utility networks.

Bentley Systems is based in Exton, Pennsylvania, USA but has development, sales and other departments in 51 countries around the world.”

[http://en.wikipedia.org/wiki/Bentley_Systems, (29 September 2010)]

“Bentley Systems is Autodesk's main rival in the CAD industry and has been since it was founded in 1984. The yare still in rivalry but now it is the BIM platform they are competing on instead of the 2D drafting approach. Bentley's major product is its MicroStation Software, which has evolved form a simplistic 2D CAD tool to a complex 3-D and a total BIM capable solution. This has happened by Bentley buying companies that are making programs that fit into their future development curve of MicroStation.”

(Agustsson, G.I., 2007, Building Information Modelling and the impact on the building industry, pg 14)

By integrating these particular programs and their functions as either add-ons or plug-ins into MicroStation they have gotten an excellent result. They are constantly updating their solutions for MicroStation, either by updating the programs core functions or adding new tools to their overall software lineup. Basically what Bentley is offering to the BIM platform is more of an extension to its original MicroStation solution.

2.3.1 MicroStation V8 XM Edition

“This is Bentley’s update of its flagship CAD solution, MicroStation. This new version, with an extension calls TriForma, is furthering their 3D experience and the base to their launch of BIM platforms. In forms of add-ons to the extended TriForma version of MicroStation V8 they are offering the following BIM applications:

- Bentley Architecture
- Bentley Structure
- Bentley Building Mechanical Structure
- Bentley Building Electrical Systems
- Bentley Facilities

The first one, Bentley Architecture, is their only BIM solution focusing solely on Architecture and the one that they use as their BIM spearhead. It is an object orientated product just like its companion applications for structural and building systems engineering.

Also it is a bidirectional multi-file solution as Autodesk Architecture. Because the programs core is in fact a full version of MicroStation, it is very easy for users to start their projects in a BIM environment if they are already accustomed to the functions of MicroStation.

As Bentley offers full support with DWG files, it is even easy for Autodesk’s users to jump aboard and fell comfortable in the Bentley Environment. Even though it may seem hard to believe, the integration between Bentley Architecture and Autodesk Architecture makes a mixed platform project possible. Bentley Architecture comprises of high-quality 3-D modeling, rendering and animation functions, therefore giving the user endless possibilities for visualization. Furthermore it offers other several significant functions regarding BIM, e.g. to output schedules and reports, cost analysis, and bidirectional integration with 3’rd party engineering analysis software. It also gives the user the option to choose between working on a 2-D or 3-D environment, or both

at the same time. Meanwhile the program keeps all the relevant data and drawings up to date and organized with its built-in Project Explorer. Bentley Architecture is also very appealing for firms dealing with large and multidiscipline projects as the software's format exchange capabilities are excellent. So it is no surprise that the program is being used on many high profiled projects around the world by some of the biggest firms in the industry, like Ove Arup and Norman Foster as prime examples. Furthermore Bentley's software solutions are being used for the renovation of one of the world's largest office building, the Pentagon. This project is enormous in size as it will cost around \$1.2 billion and will take around 15 years to be fully completed."

(Agustsson, G.I., 2007, Building Information Modelling and the impact on the building industry, pg 14)

2.4 Nemetschek

"The Nemetschek group (Nemetschek AG) is world leading vendor of software for architects, engineers and the construction industry. The company develops and distributes solutions for designing, building and managing buildings and real estate as well as multimedia."

[\[http://en.wikipedia.org/wiki/Nemetschek\]](http://en.wikipedia.org/wiki/Nemetschek), (29 September)

"Nemetschek has been developing CAD software since 1985 and have become one of the biggest software vendors in Europe, especially after buying one of their biggest rivals in the business, Graphisoft. Graphisoft was founded in 1982 in Hungary and that is when it started developing its main product, ArchiCAD. Nemetschek has now an excellent portfolio of CAD software to boast of, and with its acquiring of ArchiCAD their BIM capable platforms are up to three in total. Nemetschek's flagship product is VectorWorks, a CAD program both for Macintosh and Windows machines, much like ArchiCAD. Another interesting program they development which is growing fast in Europe and Germany especially, is their 3D CAD software solution

called Allplan. It will be interesting to see what will happen in the future development of these different programs. Right now they are selling them as totally separate products and competing with themselves, as well as the other vendors. “

(Agustsson, G.I., 2007, Building Information Modelling and the impact on the building industry, pg 16)

2.4.1 Graphisoft ArchiCAD

“In the beginning it was only for Apple Macintosh and it was a popular product. It is recognized as the first CAD product, on a personal computer, able to create both 2-D and 3-D drawings so it was quite ahead of its time. Today more than 100.000 architects are using it in the building industry. ArchiCAD has always worked with the so called “smart objects” which is the program’s function of working with parametric objects. This was totally different from the way other drafting programs functioned at the start of the CAD-age. In ArchiCAD the user creates a so called “virtual building”, with virtual structural elements like walls, slabs, roofs, doors and windows. A large database, of pre-designed customizable objects, comes with the program when purchased.

ArchiCAD is capable of working either in a 2-D or 3-D environment on the screen, whichever the user prefers. The 2-D drawings can be exported easily even though everything is embedded in a 3-D model database. The program is a bidirectional single file solution, consisting of the PLN file format. ArchiCAD uses a geometric description language (GDL) to create the models. Plans, elevations and sections are generated from the 3D model and are constantly updated when objects are modified. Detailed drawings are based on enhancing a particular part of the building and adding 2D detail to that specific part. That info can then be extracted as a separate drawing. There are many 3’rd party

plug-ins available for the program and one of those is between ArchiCAD and Cinema4D, one of the most prestigious 3D NURBS modelling tools available. This might be interesting for potential users of ArchiCAD focused on organic shaped 3D modelling as this offers the capability of making complex shapes but still keeping them fully parametric and “intelligent”. ArchiCAD is one of the very few CAD programs available both for Macintosh and Windows platforms. As it has been around for a long time and the first to actually implement 3D parametric modelling it is regarded as an excellent BIM solution.”
(Agustsson, G.I., 2007, Building Information Modelling and the impact on the building industry, pg 16)

2.4.2 Nemetschek VectorWorks Architect

“VectorWorks Architect is developed by Nemetscheck and is a cross-platform BIM solution, as it is available both for the Macintosh and Windows, same as ArchiCAD. It is regarded as the cheapest BIM solution in the market today, so smaller firms with a limited budget are its main target group. The program boasts of excellent 3D modelling features in addition to its robust 2D drafting and detailing capabilities. The program gives the user freedom, similar to most other BIM platforms, to choose between working in a 2D or 3D environment. Everything is object based and those objects have the capabilities to add non-graphical information like materials, procedures and pricing. The program is developed as a bi-directional single file solution, similar to ArchiCAD and Revit respectively.

This information can be accessed and printed out for revision during the design process. Furthermore the programs built in worksheet function offers the user to create schedules, reports and tables that are connected to the object in the model.

The best feature of the program is the use of NURBS in the 3D modelling part, which makes it possible to create complex surfaces and organic shapes. VectorWorks Architect also has an included visualization module, RenderWorks, allowing users to create photorealistic renderings. The program is as well compatible with DWG and DXF format, which makes transition and multidisciplinary projects possible. Studio Daniel Libeskind is one of the more famous users of VectorWorks. He used the program to design his winning entry in the World Trade Centre competition for the Freedom Tower, but sadly was demoted by the sites lease owner to focus his design on the master plan of the site. That meant his elegant tower proposal was swapped with the current proposal of the Freedom Tower which Skidmore Owings and Merrill were granted to design.”

(Agustsson, G.I., 2007, Building Information Modelling and the impact on the building industry, pg 17)

2.4.3 Nemetschek Allplan

“Nemetschek has been developing this particular software since 2005. The Allplan software is regarded as a capable BIM solution and has two different variations.

- Allplan Architecture
- Allplan Engineering

Allplan Architecture is a solution that covers the design process from the sketching phase to detailing and construction documents phase. The program allows the user to build a model both in a 2D and 3D environment, whichever is preferred. The capability to modify and to view a project in both 2D and 3D speeds up the design process and gives immediate feedback. Allplan Architecture is an object orientated solution, meaning that each time a modification occurs to any object in the model an automatic adjustment happens to all other parts of the model simultaneously.

Allplan has its own system of reference planes which are used to define plans, ceilings, roofs, which makes the 3D modelling procedure faster and easier. Furthermore Allplan boasts of excellent drafting tools, functions that easily match any other CAD tool on the market.

And with its companion product for engineering purposes, the Allplan Architecture software is more than capable of delivering a profound BIM solution to its users.”

(Agustsson, G.I., 2007, Building Information Modelling and the impact on the building industry, pg 18)

2.5 Gehry Technologies

“Frank O. Gehry is often talked about as one of the “Starchitects” or celebrities of Architecture alongside Zaha HADID, Norman Foster, RemHoolhaas and more. This is due to the fact that he has made an incredible contribution to the whole industry, not only by leading as an example in designing many of the most prestigious buildings of the 20th century, but mainly for developing a piece of software that utilizes the BIM approach. His company, Gehry Technologies, in collaboration with a French software company called Dassaults Systems, has developed an add-on to Dassaults CATIA program. That program remains as the number one design software used by the automotive and the aeronautic industries to make their respective products. This add-on for CATIA is purely intended for the building industry. Frank Gehry’s design of the Guggenheim Museum in Bilbao would probably not have been build able if he would not have used BIM methodology with the whole design process. As it was built over 10 years ago, before any BIM tools were a common feature in the AEC industry, his mixture of programs like RhinoCeros, AutoCAD and CATIA made it possible for him to realize his innovative design. The best and most surprising part was that the finished project was under the initial budget, even though the shape of the building was extremely complex.

By utilizing CATIA he was able to construct digitally the steel framing for the building exactly how it was supposed to be assembled.

This made it easier for the steel contractor to give their price at the tendering phase of the project, as quantities, problematic areas and details were already solved. After these positive results, there was no way he would not keep using the BIM approach for his upcoming projects. This is where he started developing digital project, the add on to CATIA, so it would be easier for him to manage this new methodology. “(Agustsson, G.I., 2007, Building Information Modelling and the impact on the building industry, pg 20)

2.5.1 Digital Project

“This revolutionary software platform developed for building tams that want to use digital technologies to realize their most ambitious building projects. In a digital environment the program supports the whole project lifecycle process from the initial concept phase, through the design phase and construction documents and even the on-site construction phase.

As Digital Project is built on top of CATIA, the high performance technology software that has revolutionized the aerospace technology and manufacturing industries, it comprises of the best available digital tools for the project teams working on complex building designs and construction.

The platform offer user the ability to create a comprehensive project database and allows teams to use the full benefits of the Building Information Modelling Methodology, including the following:

- Better overview of the project status and the information created by the project team during the design process.
- Accurate cost estimating capabilities

- Offers integration of financial data and other project relevant information with the database and its virtual building components.
- Minimizes errors and omissions in construction documents which reduce the need for rework, especially on the site.
- Better coordination between drawings and easier delivery of project data
- Capability to integrate drawings and documentation with fabrication or construction activities.
- Reduces the paper-trail, e.g. paper printing and its cost.

The best example of his recent projects which utilizes the capabilities of Digital Project is the Walt Disney Concert Hall in Los Angeles.

The structure is often resembled to the Getty Centre in Balboa as the complexity of shapes and material selection is similar.

It will be interesting to see what and how Gehry Technologies will market this product, as right now it is not that easy to acquire a demo version to try out the software. They do offer educational versions but that has the attachment for students wanting the software need to have the backing of their respective schools to be able to get the program. This makes it difficult as students usually have little influence on what software is thought in their education.”

(Agustsson, G.I., 2007, Building Information Modelling and the impact on the building industry, pg 19)

2.6 Summary

The four companies, namely Autodesk, Bentley, Nemetschek and Gehry Technologies are at this stage the names to look out for when in the market for BIM software. The programs offered by these companies are very much alike, and productivity achieved is dependant on the user’s skill and knowledge. The user must be familiar with the software

at hand otherwise the various features of the program are meaning nothing. Another aspect to look at when choosing a product will be the industry norms. At this stage to due Autodesk's large user base, the DWG file format has become the industry standard. Most of the other products are however also capable of reading and writing in the DWG format. It is also important that a solution is chosen that supports the open source data exchange format, Industry foundation classes (IFC). This new standard format makes it possible for teams using a wide variety of software to find the workflow that suits their project needs and technology choices.

2.7 Statement of Hypothesis

The hypothesis of this chapter is there are several different companies marketing BIM products at this point in time. It would seem that companies become confused with which product to choose.

The chapter takes a look at the products offered by the different companies, and one can see that the products are very similar in function. The final decision on which product to choose will always lie with the company, which will need to choose the program that best fits their specific need and workflows. The hypothesis has been proven correct, as studies have shown that companies are confused of the functions and use of the different packages available to them.

Chapter 3- What are the benefits and advantages of implementing BIM in the local construction industry?

Building information is the “process of developing building model which is used in presenting and visualizing building components, construction sequences, resource allocation and other disciplines of construction process in a virtual environment.”

[<http://www.buildingsconstruction.co.cc/what-are-the-benefits-of-bim-advantages-in-building-planning.htm>, (28 February 2010)]

The benefit and advantages are therefore far reaching, and influence almost every step of the life cycle of a project. This is from the pre-construction or planning phase, through construction to post construction.

“Owners can benefit from BIM post-construction by using 3D (three dimensional) drawings to visualize a space, review layout changes, and approve remodels or redesigns. BIM also opens the door for analyzing operations data such as energy use, allocating and managing assets, and facilitating maintenance. “

[<http://www.mii.com/site/frameset.aspx?siteid=0&langid=1033&main=/page/open.asp%3Fpid%3D11422>, (2 March 2010)]

Building information modelling is continually gaining increasing support from building owners, architects, engineers, quantity surveyors and general contractors.

An Extensive list of the benefits of BIM at the various stages of a project and for the different parties involved in the different stages of a project is as follows:

3.1 Benefits to the parties at the different project stages

3.1.1 Benefits at Planning

3.1.1.1 Benefits to the Planner/Designer

-“Use of Program Design tools such as Trelligence Affinity, which will link the project’s program to other BIM tools such as Archicad and Revit.

-Use of integrated analysis tools such as Ecotect, IES Virtual Environment and Green Building Studio afford better environmental design aspects much earlier in the design process.”

http://communities.bentley.com/blogs/dean_bowman_bentleys_blog/archive/2007/09/28/what-does-a-contractor-need-to-get-from-design-part-1-advantages-of-computer-models.aspx,(20 March 2010)]

3.1.1.2 Benefits to the Cost Engineer

-“Utilizing more accurate quantities from a building information modelling source.

-Tools such as Innovaya and Autodesk QTO typically use data extracted from Revit or Archicad and combine the quantities with cost databases such as Sage Timberline Office.”

http://communities.bentley.com/blogs/dean_bowman_bentleys_blog/archive/2007/09/28/what-does-a-contractor-need-to-get-from-design-part-1-advantages-of-computer-models.aspx,(20 March 2010)]

3.1.1.3 Benefits to the Owner

-“Using accurate, 3D information models can help owners make more informed decisions about the feasibility of a proposed project.

-Tools such as Beck DProfiler or the Onuma Planning System fit this profile.”

[http://communities.bentley.com/blogs/dean_bowman_bentleys_blog/archive/2007/09/28/what-does-a-contractor-need-to-get-from-design-part-1-advantages-of-computer-models.aspx](20 March 2010)]

3.1.2 Benefits at Design

3.1.2.1 Benefits to the Architectural Designer

-“Reduces administrative work allows focus on design

-Assists with faster coordination of disciplines

-Automates drawing set navigation

-Allows model checkers to assist with quality control”

[http://communities.bentley.com/blogs/dean_bowman_bentleys_blog/archive/2007/09/28/what-does-a-contractor-need-to-get-from-design-part-1-advantages-of-computer-models.aspx](20 March 2010)]

3.1.2.2 Benefits to the Electrical Designer

-Improved coordination of electrical systems – prevent clashes with other systems like plumbing, structural elements and mechanical systems

[http://communities.bentley.com/blogs/dean_bowman_bentleys_blog/archive/2007/09/28/what-does-a-contractor-need-to-get-from-design-part-1-advantages-of-computer-models.aspx](20 March 2010)]

3.1.2.3 Benefits to the Mechanical Designer

- Improved Coordination with other disciplines and contractors
- Added efficiency to generate documents
- 3D geometry with spatial relationships and attributes
- Easily extract HVAC data from the 3D Model
- Integration with Energy Analysis applications such as IES VE
- Data for building commissioning and recommissioning is readily available

http://communities.bentley.com/blogs/dean_bowman_bentleys_blog/archive/2007/09/28/what-does-a-contractor-need-to-get-from-design-part-1-advantages-of-computer-models.aspx,(20 March 2010)]

3.1.2.4 Benefits to the Plumbing Designer

- “Fixture schedules can be synchronized or linked to the architects schedule with a mere key stroke if desired.
- Fixture schedules, plans, riser diagrams, sections and details can be automatically synchronized
- Designer and his/her collaborators can visualize fixture layout and piping in 3D throughout the design process.
- Collisions and interferences can be determined immediately and automatically by software and integrated designs. NO MORE RFIs to process, BIM contains the information needed.
- Riser diagrams can be developed once and then automatically synchronized with the plans. All engineering data, (such as drainage fixture units) can be automatically and continuously followed in plan and analyzed in a variety of views and filters.
- Revisions to the plan, including architecture, can be checked in much less time compared to CAD or drafting methods.
- Designer can add, delete, and modify fixtures and outlets easily with automatic update to the engineering data and the model.”

[\[http://communities.bentley.com/blogs/dean_bowman_bentleys_blog/archive/2007/09/28/what-does-a-contractor-need-to-get-from-design-part-1-advantages-of-computer-models.aspx\]](http://communities.bentley.com/blogs/dean_bowman_bentleys_blog/archive/2007/09/28/what-does-a-contractor-need-to-get-from-design-part-1-advantages-of-computer-models.aspx),(20 March 2010)]

3.1.2.5 Benefits to the Landscape Designer

- “Ability to analyze costs
- Strategize irrigation systems more thoroughly
- Run sun studies to find the best locations for plants”

[\[http://communities.bentley.com/blogs/dean_bowman_bentleys_blog/archive/2007/09/28/what-does-a-contractor-need-to-get-from-design-part-1-advantages-of-computer-models.aspx\]](http://communities.bentley.com/blogs/dean_bowman_bentleys_blog/archive/2007/09/28/what-does-a-contractor-need-to-get-from-design-part-1-advantages-of-computer-models.aspx),(20 March 2010)]

3.1.2.6 Benefits to the Structural Designer

- “Faster generation of structural detailing drawings
- Optimized parameters of the structural model following design rules
- Less approximations, more refined engineering design based on sound theory
- Integrated modelling, analysis and design (instead of splitting up the tasks)
- Better cooperation with the architectural designer and HVAC designer by exchanging models
- More attention to cost factors by studying alternative solutions on one model
- Integration with CAE solutions to achieve better and optimized constructions”

[\[http://communities.bentley.com/blogs/dean_bowman_bentleys_blog/archive/2007/09/28/what-does-a-contractor-need-to-get-from-design-part-1-advantages-of-computer-models.aspx\]](http://communities.bentley.com/blogs/dean_bowman_bentleys_blog/archive/2007/09/28/what-does-a-contractor-need-to-get-from-design-part-1-advantages-of-computer-models.aspx),(20 March 2010)]

3.1.2.7 Benefits to the Cost Engineer

- “Measures construction costs like total project cost per square foot, construction contract cost per square foot, and construction change order costs and percentages
- The entire scope of a project – from design, scheduling and costing to contracts, purchase orders, change requests, as-build’s and completion – is all reliably and digitally co-ordinated.”

http://communities.bentley.com/blogs/dean_bowman_bentleys_blog/archive/2007/09/28/what-does-a-contractor-need-to-get-from-design-part-1-advantages-of-computer-models.aspx,(20 March 2010)]

3.1.2.8 Benefits to the Specifications Writer

- “Generate draft specification from materials and systems embedded in model
- QC specification against model for verification
- Single data points for drawings, specifications, estimate, construction”

http://communities.bentley.com/blogs/dean_bowman_bentleys_blog/archive/2007/09/28/what-does-a-contractor-need-to-get-from-design-part-1-advantages-of-computer-models.aspx,(20 March 2010)]

3.1.2.9 Benefits to the Owner

- “Rapid design from using “kit of parts” or dynamic prototyping approach
- Standardized facility production increases productivity and economies of scale for IDIQ contract approach – USACE
- Accurate numbers for leasable space – GSA
- Best way to maximize investment for Design, Build, Own and Maintain
- Analyses are done during design to improve the building’s performance rather than having to change an existing facility later.”

[\[http://communities.bentley.com/blogs/dean_bowman_bentleys_blog/archive/2007/09/28/what-does-a-contractor-need-to-get-from-design-part-1-advantages-of-computer-models.aspx\]](http://communities.bentley.com/blogs/dean_bowman_bentleys_blog/archive/2007/09/28/what-does-a-contractor-need-to-get-from-design-part-1-advantages-of-computer-models.aspx),(20 March 2010)]

3.1.3 Benefits at Construction

3.1.3.1 Benefits to the Construction Manager

-“Toolbox talks can now use visualization for relaying information for safety or quality

-Phasing

-Sequencing

-Logistics Planning

-Scope clarification during bidding”

[\[http://communities.bentley.com/blogs/dean_bowman_bentleys_blog/archive/2007/09/28/what-does-a-contractor-need-to-get-from-design-part-1-advantages-of-computer-models.aspx\]](http://communities.bentley.com/blogs/dean_bowman_bentleys_blog/archive/2007/09/28/what-does-a-contractor-need-to-get-from-design-part-1-advantages-of-computer-models.aspx),(20 March 2010)]

3.1.3.2 Benefits to the Construction Contractor

-“Visualize what is to be built

-Collaborative review

-Interference checks (e.g., fire suppression piping running through the ductwork)

-Rehearse construction plans and sequences

-Rehearse heavy lifts and difficult carry-in movements

-Rehearse yard operation and site logistics

-More “what if” scenarios made possible by the sum total of all the “rehearsal” options

-Plan errors are found when building the models. Hence, fewer errors and omissions requiring corrections by the contractor and additional bills to owners.

- Saves time in staking out the project
- Enable GPS driven machine control equipment
- Provide a platform to study, plan and insert temporary construction such as scaffolding
- Fewer surprises in the field
- More prefabrication of materials and even some assembly in a controlled, factory environment which typically results in higher quality at a lower cost.
- Makes it possible for non-technical people to better visualize the final result
- Fewer call backs and lower warranty costs
- Reduced risk
- Less construction material waste”

[http://communities.bentley.com/blogs/dean_bowman_bentleys_blog/archive/2007/09/28/what-does-a-contractor-need-to-get-from-design-part-1-advantages-of-computer-models.aspx,(20 March 2010)]

3.1.3.3 Benefits to the Owner

- “Visualizing helps the owner’s groups see what they will be getting resulting in dealing with less change orders during construction
- Issues resolved in trade coordination, makes for more streamlined installation resulting in better quality construction
- Assists in public marketing material”

[http://communities.bentley.com/blogs/dean_bowman_bentleys_blog/archive/2007/09/28/what-does-a-contractor-need-to-get-from-design-part-1-advantages-of-computer-models.aspx,(20 March 2010)]

3.1.4 Benefits at Maintenance

3.1.4.1 Benefits to the Occupant

-Facility management

3.1.4.2 Benefits to the Owner

-Facility Management

3.1.4.3 Benefits to 6D – Sustainability

-“Green BIM: Successful Sustainable Design with Building Information Modelling

-BIM and LEED: BIM Functionalities vs. Green Building Performance Requirements

-BIM supports IPD, which is crucial for the success of green design, e.g. the design charrette process

-Green strategies, such as LEED strategies could be supported by the alternative design functionalities of most current BIM software solutions

-Building Performance and Energy Analysis (BPEA) using BIM through cutting-edge energy simulation solutions, CFD, Lighting Design (Radiance) and to name a few.

-QTO and Intelligent 3D objects can capture material contents, attributes and other information that are crucial to provide project team a full control of material input into the project. Recycled content, rapid renewable material percentage, regional materials, even embodied energy could be obtained from the BIM model

-Integration of GIS into BIM could support sustainable site development, including development density analysis, brown field development analysis, public transportation access, and to name a few.

-Help monitor impacts of buildings on climate change, noticeably the carbon emission potential. By entailing the power of Energy Management System and other Intelligent Building strategies, BIM will be able to monitor the energy resources and consumption, which could then be interpreted into Carbon Emission potential. A more rigorous strategy could be performing a LCA of green building using BIM, and establish the benchmark of carbon footprint for green buildings.

-Promote productivity and residents health in built environment. IAQ control through well thought strategy during design stage; HVAC design considering the well balanced natural and mechanical ventilation, thermal comfort requirements of residents; monitoring of carbon dioxide concentration and other VOCs concentration; open space and day lighting design... All these could be potentially achieved through BIM. “
[\[http://communities.bentley.com/blogs/dean_bowman_bentleys_blog/archive/2007/09/28/what-does-a-contractor-need-to-get-from-design-part-1-advantages-of-computer-models.aspx\]](http://communities.bentley.com/blogs/dean_bowman_bentleys_blog/archive/2007/09/28/what-does-a-contractor-need-to-get-from-design-part-1-advantages-of-computer-models.aspx),(20 March 2010)]

3.1.4.4 Benefits to 7D - Safety

-“Design for Safety

-OSHA regulation integration into BIM model

-Code Checking such as CORENET in Singapore”

[\[http://communities.bentley.com/blogs/dean_bowman_bentleys_blog/archive/2007/09/28/what-does-a-contractor-need-to-get-from-design-part-1-advantages-of-computer-models.aspx\]](http://communities.bentley.com/blogs/dean_bowman_bentleys_blog/archive/2007/09/28/what-does-a-contractor-need-to-get-from-design-part-1-advantages-of-computer-models.aspx),(20 March 2010)]

As can be concluded from the above, the benefits of building information modeling affect almost all individuals involved in the different stages of a project.

In conjunction to the benefits of Building information modeling, there are a number of general advantages offered by the use of the system.

These advantages are as follows:

3.2 Main Advantages of implementing Building information modelling

3.2.1 Improved visualization:

“BIM is an integrated workflow built on coordinated, reliable information about a project from design through construction and into operations. The Revit platform is purpose built software for building information modelling. BIM enables architects and engineers to use digital design information to visualize, stimulate and analyze their projects real world appearance, performance and cost.”

(http://drh2.img.digitalriver.com/DRHM/Storefront/Company/adsk/files/pdf/Learning_Autodesk_Revit_Architecture_2010-Sample_Ch.pdf)

“The prediction of how an architectural design will influence occupants, visitors, neighbours, and how these will react to and interact with the building is crucial to the design. These influences are endless, and include the shadows that the building will cast, how will influence wind, and the flow of water in the area, the lighting on the inside of the building to positions of elevators and so on. Most architectural drawings are in 2D. The extent to which a client is able to visualize the building before construction is completed, therefore relies largely on the ability of the client to be able to interpret 2D drawings. Most clients are not experts in the construction industry, and this ability is often very limited. This is relevant to all parties involved in the project, including contractors and other parties. The other alternative up to this point in time has been models and artists renderings of the drawings. These are hampered by the cost though. Also changes made to the project become costly to change on artists drawing and models. BIM introduces

the ability to render drawings in, through using visualization software, in 3 dimensions. This creates the ability to communicate drawings through 3D shaded views, photo like renderings and animated walk through.

These types of design visualizations are a lot more effective in communicating a 3D design, and are being widely at this stage. These rendering can be used not only for creating an understandable representation of the building, but also for analysing the different components of the building, as for instance the casting of shadows, and the lighting of the building.”

[http://images.autodesk.com/adsk/files/bim_designvisualization_whitepaper.pdf, (5 April 2010)]

3.2.2 Improved productivity due to easy retrieval of information:

This is an extremely valuable asset of BIM. What Autodesk software has created is a platform to which all parties of the project link, and is able to retrieve information. The entire system is designed to function of a server that can be individually accessed by the different parties. This has the advantage that each user has access to up to date information the moment it is changed by another user. This minimizes the risk of design changes being missed by other parties. All parties involved can also be automatically notified by the system of changes. Changes to any drawing will therefore be immediately available to the contractor, and the risk of the contractor not receiving the most up to date revisions of the drawings is greatly reduced. Another advantage to this is that due to all the information being available on line, distances between the different parties are no longer a problem, and it will therefore be possible for the employer, design team, and construction site to be situated on different continents. Due to information being available as it is changed by one part of the design team, valuable time will be saved through by not creating situations where once a change to the design is made, the other part of the team is working on out dated drawings until

the new revisions are delivered. The programs themselves the different programs used by each specific party are also likened up to one another by using BIM. This means that party is able to use the other parties' drawings, and add their section of the work to it, instead of having to redo, or create their own drawings from scratch. An example of this is supplied below:

Revit platform users can save their information model in a 3D DWG format, which is linked directly to 3ds Max software. 3ds Max software can maintain a live data link to Revit model, so when the Revit building model changes the Revit user saves it out to 3D DWG again and the 3ds Max user just refreshes to update the visualization model. This offers seamless transfer of model data and interoperability between the applications.

[http://images.autodesk.com/adsk/files/revit_bim_and_visualization_mar08, 5 April 2010)]

3.2.3 Increased coordination of construction documents

BIM offers the following services concerning documents:

- Conversion of completed 2D construction drawings to 3D BIM models
- Development of Architectural BIM models working with architects, structural, and MEP consultants
- Development of "Builders" BIM model for general contractors
- Creation of quantity take-offs from BIM models
- Detection of collisions and clashes within BIM models
- Creating "intelligent" parametric libraries.
- BIM models meeting NBIMS / IFC standards.
- BIM models supporting analysis for sustainable design, performance assessment, building's overall energy performance, Daylight Analysis, Thermal Assessments, credit reports.

As mentioned, all parties have immediate access to the most up to date documentation. This is due to the fact that everyone is connecting to the same set of documents.

Each party's will be using separate programs to add to the document set, but the final product will be the same for everyone.

Due to the documentation being stored electronically, co-ordination of the documents will be more easily manageable, and duplication will greatly be reduced.

3.2.4 Embedding and linking of vital information such as vendors for specific materials, location of details and quantities required for estimation and tendering

BIM will be valuable assets to the cost estimating of projects in the future. This is due to the fact that purpose designed programs will enable computers to understand a model as a building. Any part of the building, for instance a wall will know what it is and how to react in relation to the rest of the building. Therefore it will be able to be scheduled and quantified by the program. Computable building information supports many building designs and construction activities as: Structural analysis, MEP System modelling, building energy analysis and specification management to name a few. Cost Estimating or quantity surveying will benefit from computable building information. As architects are responsible for the designing of the building, cost estimators take over the task of quantifying the building. Quantity surveyors usually start off by digitizing the architect's drawings or taking of quantities manually. These methods bring in the risk of human error. By using building information modelling instead of drawings, take offs and counts; measurements can be generated directly from the underlying model. Therefore information is always linked to the design itself, and immediately updated. A change in the design will immediately be captured, and the costs will then be adjusted automatically as well as the program which will automatically be updated. Time spent by

estimators/ quantity surveyors on projects varies, but this method will greatly reduce this time spent, and will therefore have big impact on the cost of quantifying the building. By reducing the time spent on pure estimating, it will be possible for estimating firms instead focus on spending more time on higher value project specific factors, as fore instance identifying construction assemblies, generating pricing, factoring risk and so on that are essential for high quality estimates. As the suppliers can be linked to BIM, they will receive up to date information as it changed to the actual drawings. This entails that suppliers will immediately be notified of any changes that occur to them. Change orders will be minimized, and this will have a positive impact on the cost related to the project.

3.2.5 Increased speed of delivery

As the entire system is linked and functions as a single unit and is immediately accessible to the parties of the project, the speed of delivery is greatly increase on all aspects of the project. This includes the speed of documentation being made to the parties of the project, to design changes and the quantifying and scheduling of the project.

3.2.6 Reduced costs

A reduction in cost will be immediately visible. This will be in the form of time spent on the designing and co-ordination of the documentation, as well as on the duplication of hard copies, and the printing and copying of documentation as it will be electronically accessible.

From the above it can clearly be concluded that the use of BIM offers numerous benefits and advantages to the different users.

The benefits of BIM range throughout the various stages of a project, form planning through to maintenance of the completed project.

3.3 Summary

The benefits to using BIM on a project can be experienced by the various parties of a project, including engineers, architects, quantity surveyors, town planners, contractors and clients.

The advantages of the implementation of BIM into companies are numerous, and can be summed up as follows:

- Improved visualization
- Improved productivity due to easy retrieval of information
- Increased coordination of construction documents
- Embedding and linking of vital information such as vendors for specific materials, location of details and quantities required for estimation and tendering
- Increased speed of delivery
- Reduced costs

3.4 Statement of Hypothesis

The hypothesis for the advantages of implementing BIM into the local market is that it will have great advantages for companies willing to take the steps to implement it.

An increase in productivity of professional employees is to be expected, decreasing professional fees for a specific project. Another advantage is a better quality end product.

BIM offers various advantages to companies as detailed in the above chapter. The use of BIM does influence the work force required for the completion of a specific project, especially on the design aspect of a project due to the increase in productivity. BIM also offers increased visualization which leads to a better quality end product due to being able to envision the final product better, and therefore allowing the client to make sure what has been designed fits with what has been envisioned. BIM also allows for better co-ordination of construction

documents, easy retrieval of information, increased speed of delivery and reduction of costs, which all contribute to producing a higher quality end product. The hypothesis has been proven correct, and companies willing to take the step to implement BIM can expect to benefit from these advantages.

Chapter 4- What are the problems facing companies wanting to implement BIM?

As with the introduction of any new system, there is always a reluctance to change. This has been the case from paper to electronic, 2D to 3D and BIM is no different. As with any new implementation research and planning are vital. Companies will need to look into issues associated with the implementation of BIM, and from these develop formal strategies for the implementation of BIM. "The implementation strategy also needs to address how the new solution will initially coexist with existing 2D drafting or 3D modelling applications. Wholesale abandonment of these legacy design applications is impractical and often ill advised, but as the implementation expands; the strategy may also include plans for the phased retirement of legacy systems if applicable. Firms should look at how the building information model can be accessed by related applications such as energy analysis cost estimating, and specifications. Specifically, look at the work you need to accomplish today, and match that to the tools you put in place today."

(Autodesk, 2007. Transition to BIM. Pg 2)

In the article, Growing Pains by Beck Ireland, the author has noted the following issues with the Building Information System:

- Speed of BIM
- Economy of Scale
- Outsourcing BIM

4.1 The Speed of BIM

"Notwithstanding two years of experience in BIM software, for every hour the BIM team at the Ashland, Ore.-based office of Douglas

Engineering Pacific, Inc. puts in on design time, it spends up to an additional 3 hr dealing with its characteristics and performance.

Due to the slow work speed, Companies as Hudson have postponed their own introduction to the software by a quarter or so. Instead, Hudson writes the specifications for and manages the BIM projects, leading the five team members already working in it and coordinating the trades. Hudson believes the BIM implementation curve was too slow, and that it was necessary to have someone working at a faster pace than BIM speed. The way the BIM software uses the memory on the machines is partly to blame for the slowdown in design, according to Hudson. Although the firm upgrades its computers every three years, the BIM software still clogs the machines. "It doesn't spread itself around," says Hudson, who adds the team must also make sure all other applications are closed before opening the BIM program.

The file structure required by the BIM software in Hudson's office also contributes to the slow work pace of the project. The file structure in BIM is far more critical than with CAD, according to Hudson, who adds that in CAD, the file structure can be set up within any number of parameters, can vary between firms and team members, and can be altered if necessary as a project progresses. CAD programs allow any number of ways to cross reference drawings or arrange files

On the other hand, BIM is less flexible and more susceptible to user-generated problems. However, once BIM is implemented throughout the industry, this negative attribute could quickly become an asset.

As long as AutoCAD's been around, really awkward and sometimes backward and unsystematic approaches to file structures have been encountered. Hudson hopes BIM's file structure will become a standard soon, therefore making everyone move in the same direction.

In addition, other delays can be attributed to various bugs in the BIM software. Once problems are encountered, it can cause two or three people standing around trying to fix something that should be a simple

fix. For example, in Hudson's experience, the software will show the load and circuit number of a panel, but then the model will change and the outlets will no longer be snapped to the walls. However, when that situation is corrected, the program will lose the circuit. This is different from CAD, in which you simply stretch components to their new location. "In terms of editing power, I would say it's nowhere close to CAD," Hudson says, attributing the difference to drawing systems in 2D or 3D versus building them in 3D. Editing a line or symbol is less destructive to the overall drawing than revising objects that are more representational. Currently, Hudson's team is working on a large federal project. To track the time his team spends on problems related to the BIM technology, Hudson had to set up a sub number within the project for the team members to assign their time to that would go purely to BIM software issues as opposed to design issues. "We needed to more accurately track that overhead so we know it didn't take that many hours to design the project," Hudson says. Recently, Hudson's team was able to increase speed by adding memory and adding external solid-state hard drives running Windows 7. Most of the projects in which Hudson's team uses BIM are single-story educational buildings. However, Hudson thinks it will probably be quite some time before BIM is used on small projects in the private sector.

Hudson feels only large projects could absorb the time spent on the BIM software, and that it's not worth the time for the small ones.

Yet, BIM currently isn't appropriate for large-scale projects either, according to Hudson. At this stage the demands of a large project in terms of the size of the model and amount of information are really pushing the limits of what BIM software can deliver.

It's certainly not cost-effective for small projects, notes Hudson, but as a production tool it leaves a lot to be desired for large projects."

[Ireland, B., 2010. Growing Pains. EC&M. Available from:

http://ecmweb.com/design_engineering/building-information-modeling-problems-20100301/ (Accessed 15 May 2010)]

4.2 Economy of scale

Three years ago, as the design build manager at a California-based electrical contractor; Michael Sine was part of a project team using BIM on the design and construction of a public elementary school.

Although Sine believes BIM can be valuable tool when used correctly on the right size project, this one was too small. The design of the 2-story school consisted of tilt-up concrete walls and contained classrooms, hallways, and a kitchen. Because of the size of the project, the preconstruction phase grew out of proportion with the design requirements. There were multiple design charrettes, which resulted in prolonged discussion. “There were a couple of instances where they took too long and didn't always realize the impact on anyone else,” says Sine. Moreover, the project was not complex enough to warrant the amount of detail put into the BIM 3D models and database.

“The customer wasn't sophisticated enough to use the information,” says Sine. “Unless you start getting things over a couple of inches in diameter, it doesn't make sense to model it.” At the construction site, an overbuilt model can delay the work. To access the model, there must be a computer equipped with viewing software on-site. In addition, a dedicated BIM team member must have the knowledge to manipulate the model and address any changes. With such a large model and an inexperienced team member, access to the design sometimes required two or three team members. Yet, despite the amount of detail, other components that should have been included in the design, such as footings, were left out of the model. The seismic requirements in California require an undisturbed “angle of deflection,” which is the 45° angle around the footing. “The locations were picked under the premise that it would not be a problem for us to stub up anywhere,” says Sine.

“It was a problem, but the issue was sloughed off even after we tried to explain to the team that we really needed to take the time to model the footings. Only those in the electrical world thought that would be of use.” Missing electrical components are common in BIM software. On average, a BIM library contains more than 50,000 objects, but firms usually have to create them from scratch. “I haven't seen a lot of components within the electrical world that are modelled in 3D,” Sine says. “Even if we know it's a 75-kVA transformer, we couldn't go to a manufacturer's Web page and pull down a 3D representation of exactly what it is. We can't go in and grab a specific light fixture or a piece of switchgear or a transformer.” In the absence of a sophisticated library, most electrical engineers and contractors make up the components as a block. “If it's a transformer, it's approximately 3 in. × 3 in. × 3 in. square in the model,” says Sine. A positive evolution for BIM software regarding electrical components is the addition of energy modelling capabilities. “Energy modelling software is starting to tie a lot more into the BIM world,” says Sine, who has been focusing a way to model real loads and tie them into the BIM model. For instance, if the rooftop unit in the model is changed, the software calculates the net change in energy use. However, lighting calculations in BIM programs are still deficient. “When you get down into the lighting, the team always just looks at the engineer or the electrical designer and asks how many watts per square foot,” says Sine, who agrees that mechanical and structural components are more advanced than electrical. The structural engineer on the California school project was able to export its own CAD program into a fabrication system to have the pieces cut by laser-guided machines. Nevertheless, many smaller ancillary connecting pieces, such as bracing, gussets, and weld plates, weren't modelled within the structural drawing. “Some of the places where we were trying to put sleeves in didn't always hit quite where they were supposed to,” Sine says.”

[Ireland, B., 2010. Growing Pains. EC&M. Available from: http://ecmweb.com/design_engineering/building-information-modeling-problems-20100301/ (Accessed 15 May 2010)

4.3 Outsourcing BIM

“According to Joe Davis, 2009. P.E., LEED AP, CEO of Custom Engineering, an Independence, Mo.-based mechanical and electrical engineering firm, mechanical and electrical subcontractors have two choices when it comes to adopting BIM software and processes. The first choice is to adopt BIM and bring it in-house by investing in the hardware and software, as well as hiring a BIM technician. On average, subcontractors are smaller firms relative to general contractors, so they have a more difficult time absorbing the costs of adoption, according to the McGraw-Hill SmartMarket Report, “2009 Building Information Modelling Study.” “It’s expensive if it’s their first project, or they don’t do very many projects that use BIM,” says Davis, Furthermore, the variety of BIM software applications may add costs and also cause interoperability issues. Therefore, another option for subcontractors is to hire an engineering firm to coordinate with the project team and add the electrical or mechanical systems to the 3D BIM model.

“They can hire somebody like us on an ongoing basis or for a lump sum fee,” says Davis. “Sometimes it’s just easier to hire the service out. We can do it for much less than what would be invested.

For subcontractors not using BIM at all, the major reason is lack of client demand. However, according to the McGraw-Hill report, general contractors are increasingly mandating BIM from key trades, and owners are demanding it from entire teams. On the federal level, the U.S. General Services Administration (GSA) requires BIM for spatial validation and the U.S. Army Corps of Engineers mandates complete BIM for many of its standard building types. At the state level, both Wisconsin and Texas require BIM for new projects. Many private

owners are also mandating BIM use from their project teams. John Moebes, director of construction for Crate and Barrel, Northbrook, Ill., runs an all-BIM nationwide program.

“More and more, general contractors are requiring their subs to provide BIM coordination drawings and coordinate with the other disciplines,” says Davis. “Often, the contractor is creating a 3D model and is telling the subcontractors that if you're going to work with us, you're going to have to coordinate your discipline in BIM.”

[Ireland, B., 2010. Growing Pains. EC&M. Available from: http://ecmweb.com/design_engineering/building-information-modeling-problems-20100301/ (Accessed 15 May 2010)]

4.4 Plumbing Design

Some disadvantages of BIM in the plumbing design field according to Marvin Titlow are as follows:

Since the technology is new, the plumbing portions of these BIM programs are underdeveloped. Because models are databases, one would believe that being able to conduct performance analysis such as hydraulic calculations live in the model would be a strong point of the software. However, as of now this feature is still in development.

While isometrics can be produced in Revit MEP, the tagging features such as pipe sizing and equipment labelling do not work in 3D views, so documentation for these isometrics takes longer. Training on the MEP portions of these solutions is very hard to find due to the specialized nature of our fields. Some engineers also state that the quality of contract documents is not as good as CAD-produced documents.

The line types that contain text styles that currently are used in CAD are not available in some BIM programs. Also, when a designer is routing piping inside a vertical wall cavity from a section view, the floor plan view may not show the single line piping correctly. However, this will improve as these programs mature. The main objective of BIM is to

produce a more accurate representation of the building and all of its components, thus providing better engineered systems. More time is required to lay out an accurate BIM model in plumbing due to the entire virtual pipe the designer is modelling. If proper workflow is not followed, results can be untimely delays or increased change orders. Most of the plumbing content for these solutions, such as objects for traps or valves must be created due to the current development stage of BIM software, which can be very time consuming. Also, if other disciplines are using 2D CAD, coordination becomes much more involved because the plumbing designer no longer can take advantage of designing in the 3D environment and cannot run any automated interference checks, increasing the chances for error and liability due to the accuracy of the model.”

[Titlow, M., BIM the future of Plumbing Design. Available From: http://ecmweb.com/design_engineering/building-information-modeling-problems-20100301/ (Accessed on: 15 May 2010)]

4.5 Summary

The problems encountered by companies and employees using the BIM software can be summed up as follows:

- The learning curve – All technology has a learning curve and necessary training time. BIM is no exception to this; employees will need extensive training and exposure to the program to become familiar with the function.
- It feels lonely – A big portion of the AEC industry is not using this technology, yet.
- Tools not 100% – Not all software platforms consist of solutions for MEP, structural and civil engineering.
- Few trained in BIM – Not many newly graduated employees trained in using BIM software.
- Pro trainers are novices – The power users usually exceed the skills of pro-trainers quickly, hence no more available training except for trial

and error.

- Transition period – The AEC industry is generally longer to adapt new technology than other industries, and BIM is no different.

- BIM standards are not fully defined.

The multiple BIM products do not have the ability to communicate with one another.

- New methods of team collaboration require new definitions for individual

responsibility and liability.

- Legal ownership of collaborative digital models must be defined.

- Increased dimensional responsibility for the design team results in additional legal liability.

- Expedited processes reduce the time for the customary process of “checks and balances.”

- How does the new BIM process change financial compensation for the design team.

The disadvantages of implementing BIM is that a large initial capital outlay will be required which will be a burden to carry for the contractors taking the step to implement BIM.

This is true especially for small to medium size contractors. They are however able to hire in specialists which reduces the capital outlay.

Larger companies should be able to carry the initial costs, and it has been shown that these costs are recovered very quickly by companies.

Another big disadvantage I foresee is that many professions will become almost obsolete due to the technological advantages which will lead to job losses for certain individuals.

There will be areas within the industry affected by the introduction of BIM, but in return new areas of expertise will be required, creating new positions. As has been found in the above chapter, there are some issues that need to be addressed with the BIM system, but the feeling is

that these issues will become obsolete as the system progresses and is used by more and more companies.

4.6 Statement of Hypothesis

The disadvantages of implementing BIM is that a large initial capital outlay will be required which will be a burden to carry for the contractors taking the step to implement BIM.

Another big disadvantage is that many professions will become almost obsolete due to the technological advantages which will lead to job losses for certain individuals.

The hypothesis has been proven correct , as there are disadvantages facing companies implementing BIM. However, the problems experienced are mostly due to the system being in the beginning phase of implementation, and they do not threaten the future of BIM.

Chapter 5- How has BIM been implemented in other Countries

BIM is increasingly used as an emerging technology to assist in conceiving, designing, constructing and operating the buildings in many countries, notably in the United States. Other countries including Finland, Singapore, Denmark, and Norway have also adopted BIM at the public and private sectors.

Various methods of implementing BIM have been used in different countries. These different models adopted by public and private sector companies and organizations and this chapter aims at looking at the some of these models. The implementation of BIM depends on the size and the nature of the economy at hand. These factors are important when trying to introduce BIM in an economy.

(Wong, A.K.D., Comparative Roles of Major Stakeholders for the Implementation of BIM in Various Countries.)

5.1 BIM implementation in Finland

5.1.1 Public Sector and BIM Guidelines

Senate Properties is the public owner running pilot projects using BIM and *Industry Foundation Classes (IFC)*. There has been a growing interest by (Architectural Engineering and Construction/Facilities Management) AEC/FM companies in BIM and IFC compatibility. Their focus is to use product model technology in ordinary project work. In Finland, the BIM guidelines are being drafted as a result of the ProIT project which is an R&D project conducted with industry wide support. It developed a number of guidelines on product modelling. The guidelines are in Finnish language and cover general principles of product modelling in construction projects, product modelling in architectural design, product modelling in structural design and product modelling in building services design (Senate Properties, 2009). These guidelines

describe product modelling in details, however, these guidelines do not explain in details the data exchange specifications which could be the next step for further development in the guidelines.

(Wong, A.K.D., Comparative Roles of Major Stakeholders for the Implementation of BIM in Various Countries)

5.1.2 Private Sector and BIM Research

There are numerous private sector companies in Finland doing R&D and promoting BIM. These include Skanska Oy and Tekes for example, and have helped lead to higher utilization of BIM in Finland than in the other Scandinavian countries. The Association of Finnish Contractors is also active in promoting implementation of BIM in the industry, along with the state client (Senate Properties) whose path is similar with the addition of the need for open standards.

Research organizations and universities in Finland are running several programmes involving the implementation of BIM. Another important organization in Finland is VTT which is in the research of building product models, or building information models since the late 1980s. Finland and especially VTT actively took part in the international development and standardization of integrated BIM when the International Alliance for Interoperability (IAI) was formed in 1996. VTT is focusing on technical issues related to the downstream applications – tools that utilize the information in the models – such as different analysis, simulation and process management applications. In those tools, energy and environmental analysis tools are given more attention because these tools can reliably evaluate the environmental impacts or lifecycle costs of buildings by robust analyses and simulations. VTT intends to apply BIM for the evaluation of environmental impacts of the built environment or the sustainability of the built environment in

general. It would make it possible to use the information generated in the design phase to be used during the building operation phase. (Wong, A.K.D., Comparative Roles of Major Stakeholders for the Implementation of BIM in Various Countries.)

5.2 BIM implementation in Norway

5.2.1 Public Sector & BIM Guidelines

In Norway, the civil state client Statsbygg has promoted the use of BIM, as well as the Norwegian Homebuilders Association. Norway's BIM guidelines are called BIM manual. These guidelines are based on the experiences from the Statsbygg's HIBO project. The BIM manual is delimited to the Norwegian standard NS8353 CAD manual, and it is prepared in coordination with the NBIMS standard in the USA. This manual was actually for Statsbygg's use however it is now also being used by other parties in Norway as well (Wong, A.K.D., Comparative Roles of Major Stakeholders for the Implementation of BIM in Various Countries)

5.2.2 Private Sector & BIM Research

In private sector Selvaag-Bluethink is developing BIM and ICT solutions based on BIM. SINTEF in Norway is the leading organization conducting research in BIM. It is a part of Erabuild which is a network of national R&D programmes, focussing on sustainable tools to improve construction and operation of buildings.

From Norway, the Research Council is the funding organization for Erabuild. Norway is among the first few countries to develop IFD (International Framework for Dictionaries) standard in the building construction regime (i.e. ISO 12006-3) which is an initiative for global

application. About 22% of the AEC/FM companies in Norway have used or implemented BIM or IFC enabled BIM.

SINTEF is also working on several internal and cross-department projects under buildingSMART initiative besides developing BIM Guidelines.

BuildingSMART is a national coordinating effort to focus and collaborate on all building development and implementation projects. Under Norwegian University of Science and Technology (NTNU), several student projects and thesis proposals are focused on buildingSMART technology and are being conducted in collaboration with industry and research organizations to develop student courses.

Norwegian IAI Forum is developing the definitions of the requirements on the information exchange under IDM (Information Delivery Manual) (IAI Forum Norway, 2007). The aim of the IDM is to support the information exchange requirements for business processes within the building construction industry. Through IDM, the parts of the IFC model that is necessary for information exchange between identified processes can be specified.

(Wong, A.K.D., Comparative Roles of Major Stakeholders for the Implementation of BIM in Various Countries.)

5.3 BIM implementation in Denmark

According to a survey which was carried out in 2006 (cited in Kiviniemi et al., 2008), the most commonly used BIM application among architects was Architectural Desktop with approximately 35% of the firms using it. It was followed by Archicad, Revit and Bentley Architecture.

Denmark has slight edge on other Scandinavian countries in prescribing by specific modelling standards/guidelines in their construction works by the clients. These requirements have already been stated by the government and some of them are part of the law.

4.3.1 Public Sector and BIM Guidelines:

In Denmark, there are at least three public owners who have initiated the work on BIM. These include The Palaces and Properties Agency, The Danish University and Property Agency and Defence Construction Service. In Denmark, although the governmental projects do not represent a large part of the total property area, their impact on the market created by the IFC requirements is big.

Denmark has actively put forth its requirements for using BIM in the governmental projects. Such requirements from the government are known as Byggherrekraevne (Det Digitale Byggeri, 2007). The architects, designers and contractors participating in governmental construction projects have to utilize a number of new digital routines, methods and tools starting from January 2007. The initiative is called 'Det Digitale Byggeri' in Danish which means 'the Digital Construction'. Since the initiative is still under experimentation, the governmental clients have exercised flexibility in its use.

The use of 3D models in the projects has been related with the price of the project. For projects above 5.5 million Euros, 3D models in the design have to fulfil a number of requirements regarding content, information levels for the various phases, which are to be defined by the client for individual project. The models are recommended to be exchanged using the IFC format. Also there are a few municipalities and private clients in Denmark who demand for object based modelling. This was accomplished under the Digital Construction program initiated by the Danish Enterprise and Construction Authority. A package of guidelines regarding 3D was developed. The guidelines concerned both the setting up and fulfilling requirements in file and database based CAD/BIM applications. These guidelines are also available in English which include: 3D CAD Manual 2006, 3D Working Method, 3D Working Methods and Layer and Object Structures 2006. (Wong, A.K.D.,

Comparative Roles of Major Stakeholders for the Implementation of BIM in Various Countries)

4.3.2 Private Sector and BIM Research:

In the private sector 'bips' is developing BIM guidelines and Rambøll is working for collaboration between Rambyg and IFC. 'Bips' has adopted the results from the Digital Construction project and are promoting the new working methods to all companies in the Danish Construction Industry. Rambøll is the main organization in Denmark performing research in BIM. Danish Enterprise and Construction Authority is an organization supporting the research in BIM in Denmark. Other organizations and universities are also performing R&D work in BIM. (Wong, A.K.D., Comparative Roles of Major Stakeholders for the Implementation of BIM in Various Countries.)

5.4 BIM implementation in Singapore

5.4.1 Public Sector and BIM Guidelines

In Singapore, Construction and Real Estate Network (CORENET) is the main organization involved in the development and implementation of BIM for government projects. It is a major IT initiative that was launched in 1995 by Singapore's Ministry of National Development. CORENET provides information services which includes e-Information System such as eNPQS and e-Catalog to its clients. It also offers integrated submission system in the form of e-Submission and Integrated Plan Checking System. IT Standards are being adopted in the Construction Industry of Singapore which has been followed from the guidelines of International Alliance for Interoperability.

Singapore has since 1997 been promoting and later on also requiring the use of BIM for various kinds of approvals like building plan approvals and fire safety certifications (Khemlani, 2005). The

CORENET e-PlanCheck defines Singapore's Automated Code Checking System and several authorities in Singapore are participating in the e-submission system, which requires the use of BIM and IFC. The BIM Guideline called "Integrated plan checking" has now been completed.

(Wong, A.K.D., Comparative Roles of Major Stakeholders for the Implementation of BIM in Various Countries).

5.5 The United States of America

There are three forces changing the capital facilities industry today: Productivity decline, advancing technology and lifecycle perspective. Research and development efforts are occurring in various organizations to understand who needs what information, when, and how will it be exchanged within and across business organizations. A few of the many efforts underway include:

The Open Geospatial Consortium (OGC), an international organization that is developing publicly available interface specifications to support interoperable solutions that "geo-enable" data used in the Web, GIS and BIM.

The Construction Operations Building Information Exchange (COBIE) is working to capture and exchange building information relevant to facility managers.

The Open Standards Consortium for Real Estate (OSCRE) focuses on data exchange within the real estate business process.

The International Code Council (ICC) is developing data and rule definitions to automate code compliance checking.

The Association of General Contractors (AGC) continues its development of exchange specifications for transactional data now commonly exchanged as paper documents, such as agreements, change orders, and submittals.

The primary organization working on interoperability is buildingSMART

International (formerly the International Alliance for Interoperability) with 13 chapters worldwide. It is a non-profit alliance of building industry participants including: architects, engineers, contractors, building owners and facility managers, building project manufacturers, software vendors, information providers, government agencies, research labs and universities. Its goal is to develop a universal standard for information sharing and interoperability of intelligent digital building models. Their major product is the IFC. In the US, buildingSMART is organized under the National Institute of Building Sciences.

There is a number of exchange formats used today to achieve varying degrees of interoperability. *Proprietary file exchange* formats such as DXF, and DWG have been successfully used in the past to exchange geometric and alphanumeric data. *Proprietary direct links*, which are custom programs that use the application program interface (API) language of the host program, can be very robust and often seamless to the user. There are also a number of *Open Standard formats*.

Extensible Markup Language, XML, is an open standard for transfer of alphanumeric data. Though the standard is open the applications are written by software companies or organizations. The application has a specific purpose and use group. A/EcXML, gbXML, agcXML and ebXML are examples used today.

Industry Foundation Class (IFC) is another open standard exchange format. It is the only format that can exchange 3D geometric object properties, organizational relations, object attributes, alphanumeric, and other BIM data. (CIS/2 is a similar open standard focused on structural model exchange) IFC data model is the only broad based object model exchange method and will likely become the international standard for building data exchange within the construction industry.

(The State of Wisconsin Department of Administration., 2009. Building Information Modelling. A Report on the current state of BIM Technologies and recommendations for implementation.)

5.5.1 Public Sector and BIM Guidelines

On July 1, 2009, Wisconsin became the first state to require the use of BIM on public projects. The BIM requirement applies to the performance of A/E services under a design-bid-build delivery system on any large construction project, defined as those projects with a total funding of at least \$5 million, or any new construction with at least \$2.5 million in funding. BIM use is encouraged, but not required on all other projects. Wisconsin also issued its BIM Standard and Guidelines document to facilitate the implementation of BIM on applicable projects. One month later on August 12, 2009, the Texas Facilities Commission (“TFC”) announced that it was requiring the use of BIM on all public design and construction projects. Like Wisconsin, the TFC (through its Facilities Design and Construction division) had been studying the use and impact of BIM and developed a set of BIM standards and guidelines and an interoperable BIM template to facilitate and standardize BIM implementation. The Texas announcement went even further than its northern counterparts by eliminating the minimum threshold project value for the use of BIM. This requirement will extend to all real estate development (including the state university systems) for the state of Texas.

(Drewry, DM., 1 June 2010. BIM Mandate- OH to join WI and TX in requiring BIM? Available from:

<http://drewrysimmonsvoornehm.wordpress.com/2010/06/01/bim-mandate---oh-to-join-wi-and-tx-in-requiring-bim/> [Accessed on 08-09-10].)

The General Service Administration (GSA) Public Buildings Service (PBS) Office of the Chief Architect (OCA) established the National 3D-4D BIM Program in 2003 (Kam 2007). The primary goal of the program is to phase in 3D, 4D, and BIM adoption for all major projects. Additionally, the GSA hopes to create a knowledge portal community and a six-part BIM Guide Series. Currently, Series 01 and 02 are

available online in draft version with Series 03-06 in various unpublished stages. Another large owner implementing BIM is the U.S. Army Corps of Engineers (USACE.) The primary driver of all recent Army organizational changes can be attributed to “Army Transformation.” A program that piggybacks on Army transformation to support the infrastructure requirements dictated by Army Transformation is called “MILCON Transformation.” It is MILCON Transformation that drives most of the actions, and especially the recent initiatives towards change in the Army Corps of Engineers.

The National Building Information Model Standard (NBIMS) serves as doctrine for all the key members and roles of the facility lifecycle to agree on the strategic level of BIM implementation. Within the NBIMS are other resources that address operational and tactical level concerns. Operationally, these would include references to documents like the GSA BIM handbooks, the USACE BIM Road Map, or the AGC’s Contractor’s Guide to BIM. Tactically, items like the Interactive Capability Maturity Model (I-CMM) are meant to evaluate individual BIMs’ ability to create, leverage, and share information. In this way, the NBIMS answers questions about all levels of BIM.

(The State of Wisconsin Department of Administration., 2009. Building Information Modelling. A Report on the current state of BIM Technologies and recommendations for implementation.)

NBIMS establishes standard definitions for building information exchanges to support critical business contexts using standard semantics and ontologies. Implemented in software, the Standard will form the basis for the accurate and efficient communication and commerce that are needed by the building industry and essential to industry transformations. Among other benefits, the Standard will help all participants in facilities-related processes achieve more reliable outcomes from commercial agreements. The National Building Information Modeling Standard (NBIMS) Committee is a committee of

the National Institute of Building Sciences (NIBS) Facility Information Council (FIC). The vision for NBIMS is “an improved planning, design, construction, operation, and maintenance process using a standardized machine-readable information model for each facility, new or old, which contains all appropriate information created or gathered about that facility in a format useable by all throughout its lifecycle.”¹ The organization, philosophies, policies, plans, and working methods that comprise the NBIMS Initiative and the products of the Committee will be the National BIM Standard (NBIM Standard), which includes classifications, guides, recommended practices, and specifications. (National Institute of Building Sciences, 2007. National Building Information Modelling Standard. Version 1- Part 1: Overview, Principles, and Methodologies.)

5.6 Summary

The countries summarized within this chapter include the following, Finland, Singapore, Denmark, Norway and the United States of America. In all of these countries the public sector has played a major role in the implementation of Building Information Modelling. These include State departments as well as public institutions. Guidelines have also been set up in each of these countries to assist with the uniform implementation across the industry, and in line with the implementation in other countries.

In Finland public sector involvement has been of great importance, and BIM guidelines are being drafted as a result of the ProIT project which is an R&D project conducted with industry wide support.

The public sector has also played a large role in the implementation of BIM, putting Finland ahead of most other scandinavian countries in terms of utilization of BIM in Finland.

In Norway two companies have played a major role in the public sector implementation of BIM, namely Statsbygg and the Norwegian

Homebuilders Association. The guidelines for BIM developed in Norway are called BIM manual. These guidelines are based on the experiences from the Statsbygg's HIBO project, and are prepared in coordination with the NBIMS standard in the USA. In the Norwegian public sector about 22 percent of AEC/FM companies are implementing BIM.

The public sector has also been involved with setting up guidelines for the use of BIM and is one of the first few countries to develop IFD (International Framework for Dictionaries) standard.

It is also working on several internal and cross-department projects under buildingSMART initiative besides developing BIM Guidelines. In Denmark the public sector has a big influence on the market, and at least major public owners have adopted the use of BIM in their projects. Denmark has actively put forth its requirements for using BIM in the governmental projects. Such requirements from the government are known as Byggherrekravene.

In the private sector 'bips' is developing BIM guidelines and Ramboll is working for collaboration between Rambyg and IFC.

Singapore has since 1997 been promoting and later on also requiring the use of BIM for various kinds of approvals like building plan approvals and fire safety certifications. The CORENET e-PlanCheck defines Singapore's Automated Code Checking System and several authorities in Singapore are participating in the e-submission system, which requires the use of BIM and IFC. The BIM Guideline called "Integrated plan checking" has now been completed.

In the United States the primary organization working on interoperability is buildingSMART International. Its goal is to develop a universal standard for information sharing and interoperability of intelligent digital building models. Their major product is the IFC. In the US, buildingSMART is organized under the National Institute of Building Sciences. Wisconsin became the first state to require the use of BIM on public projects, with Texas being the second State to require the implementation of BIM by the Texas Facilities Commission on public

design and construction projects. Another large owner implementing BIM is the U.S. Army Corps of Engineers (USACE.).

The assistance of the public sector in the implementation of Building Information Modelling is of great importance. This is can be seen in all of the countries analyzed above. Private sector has also made a large contribution to the implementation of BIM, and a cooperative effort is required between public and private companies to establish guidelines for the implementation of BIM in industry.

5.7 Statement of Hypothesis

The hypothesis on how BIM has been implemented in other countries is that both the public and private sector will play a major role in the implementation of BIM in the industry.

The research has shown this to be true. The public and private sector in collaboration are required for the implementation of BIM.

The public sector will be mainly involved in the setting up of guidelines for the implementation of BIM and the requiring of companies to implement BIM on various projects.

The research has shown that both the public and private companies are involved in the setting up of guidelines for the implementation of BIM.

All countries have set up bodies that are involved in the setting up of guidelines, and mainly used experience gathered by both private and public companies on various projects to set up these guidelines.

Public institutions like Universities are also playing a big role in the establishment of BIM guidelines. The public sector will be responsible for the actual use of BIM on projects. The research has shown that both private and public companies are using BIM on projects.

This is due the advantages experienced by the use of BIM. These advantages are being experienced by all parties, and have greatly

contributed to the rapid expansion in the use of BIM by public and private institutions and companies.

Chapter 6- The Conclusion:

“Building Information Modelling (BIM) is the process of generating and managing building data during its life cycle

The concept of building information modeling has grown substantially over last decades due to the rapid expansion of technology, especially the use of computers in everyday life.

An “era of BIM has started in the global construction industry” and will have to be introduced into the local construction industry to stay competitive. The research has been conducted in attempt to establish the advantages and disadvantages as well as a system, for the implementation of BIM in the local construction industry. This was to be done by researching the aspects of BIM discussed in the different chapters of the research report.

There are numerous products available in the market to the end user.

The Vendors and packages on offer by each are as follows:

1 Autodesk

- Autodesk Architecture 2008
- Autodesk Revit

2 Bentley

- MicroStation V8 XM Edition

3 Nemetschek

- Graphisoft ArchiCAD
- Nemetschek VectorWorks Architect
- Nemetschek Allplan

4 Gehry Technologies

- Digital Project

Each of these presents various advantages to the user, and final decision on which package to use depends on the user himself, and the intended use of the software. This will be a very important decision for

companies as this is usually a long term endeavour, and will affect the overall success of the operation.

The benefits offered by BIM affect every stage of the project, and almost all parties to a project.

The advantages offered to the end user by BIM are numerous, and can be summed up as follows:

- Improved visualization
- Improved productivity due to easy retrieval of information
- Increased coordination of construction documents
- Embedding and linking of vital information such as vendors for specific materials, location of details and quantities required for estimation and tendering
- Increased speed of delivery
- Reduced costs

The disadvantages of BIM include the following:

- Speed of BIM
- Economy of Scale
- Outsourcing BIM

For the implementation of BIM, companies need to focus on an Implementation. A formal implementation strategy is an essential component of any successful BIM deployment and must go well beyond a simple training and rollout schedule. It needs to address head-on the work-flow and organizational changes inherent to BIM. The implementation strategy also needs to address how the new solution will initially coexist with 2D drafting or 3D modelling applications already in use. Firms should look at how the building information model can be accessed by related applications such as energy analysis, cost estimating, and specifications.

Firms should pay close attention to the make-up of the transition team.

The team should be comprised of progressive individuals who understand the big picture and will act as evangelists for BIM. Building information modelling can radically transform the process of designing, constructing, and operating a building.

But take a cue from the experiences of forward-looking firms like URS that have experienced the transition: Invest the time and energy up front to carefully plan for that transformation.

As can be seen, BIM offers many advantages and disadvantages to companies wanting to implement this product.

The advantages are very convincing, and the overall feeling is that they out way the disadvantages that have been identified.

This is mainly due to the fact that most disadvantages are only being experienced due to the system being new, and are expected to become less as the system progresses.

The assistance of the public sector in the implementation of Building Information Modelling is of great importance. This is can be seen in all of the countries analyzed. Private sector has also made a large contribution to the implementation of BIM, and a cooperative effort is required between public and private companies to establish guidelines for the implementation of BIM in industry.

The implementation of Building Information in other countries and economies has shown that collaboration between the public and private companies is necessary. The research has shown that both the public and private companies are involved in the setting up of guidelines for the implementation of BIM. All countries have set up bodies that are involved in the setting up of guidelines, and mainly used experience gathered by both private and public companies on various projects to set up these guidelines.

Public institutions like Universities are also playing a big role in the establishment of BIM guidelines.

The research has shown that both private and public companies are using BIM on projects.

This is due the advantages experienced by the use of BIM. These advantages are being experienced by all parties, and have greatly contributed to the rapid expansion in the use of BIM by public and private institutions and companies.

The research has shown that the implementation of BIM does not just offer advantages to the construction industry, but is also becoming a necessity. Countries that have started with the implementation are seeing the advantages of the system, and it is inevitable that more will follow to be able to keep up with changes in technology, client demand for more complex demands, higher quality end products and to be able to stay competitive within the international market.

It is important that companies do thorough research of the BIM system they require to accomplish the optimum results.

There are still a few problems associated with the implementation of BIM that need to be taken into account. It is however advisable to start with the implementation as early as possible, as the catching up at later stage may become very costly.

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