Implementing BIM and IPD

Focused on Refurbishment Projects in the Norwegian Construction Industry

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BATCM

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IMPLEMENTING BIM AND IPD
FOCUSED ON REFURBISHMENT PROJECTS IN THE NORWEGIAN CONSTRUCTION INDUSTRY

Title Page

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“The difference between failure and success
Is doing a thing nearly right, and doing it exactly right”
- Edward C. Simmons

Declaration
I hereby declare that the work included in this report is my own work, and that the sources used are correctly referred to.
Implementing BIM and IPD Focused on Refurbishment Projects in the Norwegian Construction Industry

Abstract

“Implementing BIM and IPD Focused on Refurbishment Projects in the Construction Industry”
By Bo Christian Trollsås, in fulfilment of Bachelor of Science at Copenhagen School of Design and Technology.

Building Information Modelling (BIM) and Integrated Project Delivery (IPD) are new methods currently emerging within the construction industry internationally as well as in Norway. The methods are expensive to implement therefore there are questions to ask when it comes to contracts and standards due to restructuring of project groups. There are also additional challenges regarding refurbishment projects, due to difficulties conducting surveys while the building is in use.

This dissertation is based on findings on the internet and reports concerning the subjects. There will also be interviews with people of interest in the industry.

My findings are that the major keys to implementation are management, the right teaching and the ability to adopt these new methods, which are here to stay. The implementation period will at first show lower efficiency, but will increase depending on the above mentioned. There will be put pressure on the delivery of a BIM model by developers and real estate owners. This will again result in opportunities for development of the application systems, which is already in motion in Norway.

All governing bodies should be more aware of what is happening in the construction industry and aid this implementation with focus on education and economically helping the companies.
Preamble

The Architectural Technologist education is in my opinion an important aspect to the implementation of Building Information Modelling (BIM) and Integrated Project Delivery (IPD). Educations like this are badly needed in the future.

For me, the choice of subject for this report was decided during this education. I knew little then of what the subject implied, but I tend to think I have learned a lot during the education and especially this dissertation.

Furthermore, I find mixing “the old, and the new” quite fascinating. Reuse is one of the keys to a sustainable future in my opinion, and especially reuse of old buildings. New technology, implemented in old structures.

The thesis will discuss BIM and IPD and what this actually means for the construction industry, and what it means for a refurbishment project, which can be one way of looking at this dissertation.

First, I want to thank my fellow student Even Teigland for the sharing of information and good debates throughout the eight weeks of work. I will also thank my colleagues from my internship company AF Gruppen, with special thanks to Ståle Brun, and Kim Fjelstad, for valuable inputs. Further I want to acknowledge my specialist advisor: Dr. James Harty, not only for the guidance through this dissertation, but also as a great inspirer throughout my education. Finally a special thanks to Simon Olafsson at CF Møller for the sharing of his experience of the implementation of BIM in his company.
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1 Introduction

Figure 1 and 2 clearly shows which direction the productivity of the building industry have had the last 20 years. Though some parts of the world have increased their productivity, the majority is still negative. In Norway, with the increase of earnings the same trend shows. (Figure 1)

How do we change this tendency and get more efficient, at the same time keep the quality of our work at a satisfactory level? It has shown that some of the major keywords are: Digitalization, BIM and IPD.

Building Information Modelling (BIM) and Integrated Project Delivery (IPD) are two relatively new guidelines of how to plan and execute a construction project. The method is hugely based on a computer model, which has the ability to include most of the information about a project. What can the industry gain of using these methods and what does it take to manage it?

Mainly, only the biggest firms have started to implement these methods, or at least BIM. The reason why the implementation is going slow, is because it means a huge change internally in the companies; new software, which again needs new knowledge, and maybe new people. That gives higher cost for the company, which again needs a good economy to be able to do this transformation. They need to realize and experience that there is possible to save both time and money, by implementing BIM and IPD by managing it correctly. But how do we convince them?

The report will focus mainly on how to implement these subjects at a refurbishment project in Norway, but in order to do so, I need to look at the whole topic.

Figure 1: General productivity within the construction industry. (http://geospatialblogs.com/geospatial/productivity/)

Figure 2: Blue line shows the productivity in the construction industry in Norway, 1990-2011. (http://boligprodusentene.no/nyheter/nye-tall-fra-ssb-viser-at-nedgangen-i-produktiviteten-i-byggenaeringen-er-langt-mindre-en-tidligere-antatt-article288-151.html)
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What makes a refurbishment project exceptional, when it comes to the subject of BIM and IPD?

First of all, the planning. At the start the competitors needs to make a survey, to find out what the condition of the building is. Preferably, the building has to be stripped to its structural parts, so that one can see clearly what needs to be done, but this is not likely. The owners needs to get the income from the renters, and then needs to keep the building usable as long as possible, and in some cases, parts of it even during the refurbishment. That means the survey needs to be done from old drawings, that most likely are not correct any longer, and some randomly chosen samples around the building. This gives possibilities of a lot of changes during the construction process, which takes time.

How can we cope with such issues? Are there any tools or systems that can support this process? This will also be one of my targets through this report.
2 Definitions

In this chapter, there will be references to what is important and understandable descriptions of the topics in query. There will be a further explanation in the main part of this report, explaining what these topics actually mean to the construction projects, and how it should be used.

2.1 Building Information Modelling (BIM)

As a short introduction, Patrick MacLeamy (CEO, HOK Architects) says:

“BIM is the first truly global digital construction technology and will soon be deployed in every country in the world. It is a ‘game changer’ and we need to recognise that it is here to stay - but in common with all innovation this presents both risk and opportunity”

More detailed described by HM Government, UK in their report:

“Building Information Modelling (BIM) is a collaborative way of working, underpinned by the digital technologies which unlock more efficient methods of designing, creating and maintaining our assets.

BIM embeds key product and asset data and a 3 dimensional computer model that can be used for effective management of information throughout a project lifecycle – from earliest concept through to operation. It has been described as a game-changing ICT and cultural process for the construction sector. A number of countries globally are starting to realise the opportunities it brings and are now investing in developing their own capability.

BIM processes are ‘mainstream’ to both new buildings/infrastructure and have further potential in ‘retrofit’ and ‘refurbishment’ projects when complementary workflows such as laser scanning and rapid energy analysis are employed. BIM technology should be seen as a ‘collaboration’ between the construction sector and the software industries and creates an environment in which there are opportunities and synergies for both.”

While the above text is describing BIM more as a method of management, BuildingSMART describes what BIM does as a tool:

1 (Blackwell, 2012)
2 (Blackwell, 2012)
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“BIM is a suite of technologies and processes that integrate to form the ‘system’ at the heart of which is a component-based 3D representation of each building element; this supersedes traditional design tools currently in use. Each component is generated from a product library and has embedded information about the product and its placement, material, specification, fire rating, U-value, fittings, finishes, costs, ‘carbon content’ and any special requirements, which are stored in the system. As the design progresses, so the integrated information becomes more valuable. Sophisticated applications and clash detection can rapidly identify issues which can be designed out at an early stage.

BIM could be mistaken for a simple design tool but this overlooks the fact that it is the way the system generates interfaces to and uses information from other systems which is fundamental to the delivery of greater benefits. These benefits accrue to the whole supply chain through the collaborative, integrated use of BIM.”

2.2 Integrated Project Delivery (IPD)

First a little history of the AEC industry, related to IPD:

... “In the 1400s, the Dome of Florence was designed by Brunelleschi, he was a Guild Master, and not an Architect. Brunelleschi designed the Dome, supervised the construction of the Dome, he even invented machinery to aid in its construction. In short, Brunelleschi was a Master Builder.

200 years later the Dome of St.Pauls in London, was designed by Christopher Wren. By this time, building designers began to call themselves Architects, and different from building guilds, the Dome was built with Wrens review, but without his supervision, further separating the role of the designer and the builder.

The Dome of the US capital was designed by Thomas U. Walter in the 1800s. By this time, Architects had formed professional societies. Walter was an early leader in the AIA (The American Institute of Architects). The US Capital Dome was constructed by a new entity; a general contractor. Walter had little involvement with the construction. The separation of the Architect and the Contractor was complete”...” Today, Architects are excited about a “new” idea; Integrated Project Delivery.

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3 (BSI/Buildingsmart, 2012)
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This idea is a good one, but it’s not new. Guilds used IPD centuries ago, IPD is an idea whose time has come again, and in the utter 50 year since we have celebrated our separateness, and forgotten the need to work together to do better and better buildings.”

What MacLeamy is actually saying here, is that IPD is a method we have practised before, but also something we evolved away from, but how does it actually work?

“Integrated Project Delivery (IPD) is a project delivery approach that integrates people, systems, business structures and practices into a process that collaboratively harnesses the talents and insights of all participants to optimize project results, increase value to the owner, reduce waste, and maximize efficiency through all phases of design, fabrication, and construction.

IPD principles can be applied to a variety of contractual arrangements and IPD teams can include members well beyond the basic triad of owner, architect, and contractor. In all cases, integrated projects are uniquely distinguished by highly effective collaboration among the owner, the prime designer, and the prime constructor, commencing at early design and continuing through to project handover.”

2.3 BIM, BAM, BOOM

BIM, BAM, BOOM Abbreviation explained:

“It all begins with BIM; the architect uses 3D modelling to investigate options and test building performance early on in order to optimize the building’s design. The design is then handed off to the contractor who streamlines the building process with BAM (Building Assembly Modelling), which allows for a significant decrease in construction costs. Once complete, BAM is turned over the owner and becomes BOOM (building owner operator model). This allows the owner to manage the building over time and ensure optimized building performance throughout its entire life cycle.”

The term “BIM, BAM, BOOM” is therefore not only a description of what the different stages is, but more a new way of thinking throughout the lifespan of the structure(s) in

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4 (HOK, 2010)
5 (The American Institute of Architects, 2007)
6 (ArchDaily, 2014)
question. This is maybe one of the most important acronyms in the building industry today, and will be explained throughout the whole report as the method of the future in the construction industry.

2.4 Industry Foundation Classes (IFC)

The IFC was an initiative started up in 1994 by Autodesk. The purpose was to develop a common way to make the different trades in a project collaborate through their software. This due to almost every profession using different programs, from different manufacturers.7

“The Industry Foundation Classes (IFC) specification is a neutral data format to describe, exchange and share information typically used within the building and facility management industry sector (AEC/FM). The IFC specification is developed and maintained by BuildingSMART International (formerly known as International Alliance for Interoperability (IAI)).

The IFC specification is written using the EXPRESS data definition language, defined as ISO10303-11 by the ISO TC184/SC4 committee. It is the same data definition language as used e.g. in STEP or CIS/2. It has the advantage of being compact and well suited to include data validation rules within the data specification. The IFC exchange file structure (the syntax of the IFC data file with suffix ".ifc") is the so called "STEP physical file" format, defined as ISO10303-21 by the same ISO TC184/SC4 committee. It is an ASCII file format used to exchange IFC between different applications.

In addition to the IFC-EXPRESS specification an ifcXML specification is published as well (since the IFC2x release). The ifcXML spec is provided as an XML schema 1.0, as defined by W3C. The ifcXML exchange file structure (the syntax of the IFC data file with suffix ".ifcXML") is the XML document structure. The XML schema is automatically created from the IFC-EXPRESS source using the "XML representation of EXPRESS schemas and data", defined as ISO10303-28 ed. 2. This ensures that both IFC-EXPRESS and ifcXML handle the same data consistently and that the *.ifc and *.ifcXML data files can be converted bi-directionally.8

7 (IAI, 1994)
8 (BuildingSMART, 2014)
2.5 Geographic Information Systems (GIS) and 3D Scanning

I will now refer to what GIS is in general to give a short introduction of the meaning of it. After this text, I will explain more what it means for the construction industry.

“A geographic information system (GIS) integrates hardware, software, and data for capturing, managing, analysing, and displaying all forms of geographically referenced information.

GIS allows us to view, understand, question, interpret, and visualize data in many ways that reveal relationships, patterns, and trends in the form of maps, globes, reports, and charts.

A GIS helps you answer questions and solve problems by looking at your data in a way that is quickly understood and easily shared.

GIS technology can be integrated into any enterprise information system framework.”

What it means, is that one can survey the building for planning purposes, and under the construction works for production purposes. This is more commonly known as 3D scanning. A company called Trimble, describes their solution like this:

“For general contractors, concrete contractors, and steel fabricators/erectors involved in renovation projects, Trimble’s 3D laser scanning solutions provide a cost effective and efficient method for gathering existing locations of structural components. Once scan data has been collected and fully registered into a usable point cloud, modelled structural components in Trimble RealWorks can be utilized as the basis for the creation of an architectural or structural model. This workflow allows contractors to work in a BIM environment using relevant data from the existing structure.”

This means that after scanning you are able to create a model in the Trimble RealWorks programme that comes with the scanning equipment, and then export it to IFC, so that you can keep on working with this in a BIM programme.

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9 (What is GIS?, 2014)
10 (Trimble, 2013)
2.5.1 Augmented Reality and GIS

“If you own a smartphone, such as an iPhone or Android, you probably have an app that uses augmented reality (AR). This technology superimposes digital information on whatever you’re looking at through your phone’s camera.”¹¹

For the construction industry, this means that if one use the smartphone/tablet with an AR application at the building site, and look at the pipes that are fitted in the ceiling through the devices screen, one will see a “what should be” image and are able to compare this with reality.

2.6 Rapid Energy Analysis

“Rapid energy modelling is a streamlined, scalable approach for performing energy assessments of existing buildings. While the umbrella term can represent a number of solutions, a typical workflow consists of three steps: capture, model, and analyse.

Step 1: First, you capture existing building conditions. Starting from as little as photos, satellite images, aerial images, or laser distance meters, you collect basic information about a building such as geometry, location, orientation, and structural or operational anomalies.

Step 2: This digital information is calibrated and converted into a simplified 3D building model. Your model can be a:

- Conceptual massing model that defines the internal volumes of the building (which is all that is necessary for basic energy modelling), or a
- Detailed model using design elements such as walls, floors, windows, roofs, and rooms or spaces.

Step 3: In this step, you analyse the building model by performing energy analyses to assess expected building performance.”¹²

2.7 Life Cycle Assessment (LCA)

“LCA is a technique to assess the environmental aspects and potential impacts associated with a product, process, or service, by:

¹¹ (Mann, 2011)
¹² (Autodesk, 2011)
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- Compiling an inventory of relevant energy and material inputs and environmental releases
- Evaluating the potential environmental impacts associated with identified inputs and releases
- Interpreting the results to help you make a more informed decision”

While this is a general explanation, the following statement links this to the construction industry:

“The impacts of a building can be split into impacts associated with waste and impacts associated with energy. The energy use can be both direct and indirect. Direct energy use is that used on site during construction, during pre-fabrication, and in transportation of materials to site. Indirect energy use is that used in producing building materials, maintaining the building, demolishing the building, and the operational energy used throughout the building’s life.”

In other words; Cradle-to-Cradle.

So, this assessment helps us understand what products and services we are using to create a building, not only at site, but also before, and after the construction. This is one of the tools we have to help us create sustainable constructions.

3 The Software in Question

This chapter will be a guide to some software solutions. The software’s in choice will be based on how profound my research has become, and the tools I am familiar with, therefore my recommendations will not necessarily be the complete solution.

3.1 Introduction

To be able to use BIM, one need the right tools. And there is a lot of them.

“The better the model the better the resulting project” I want to extend this by saying:

The better the use of the collaborating software for the different stages of the project, the better the end result.

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13 (EPA, 2012)
14 (Dixit, 2010)
15 (Harty, 2012)
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Since there is a huge variety of the different tools, there are also a huge variety of the different file formats, and this can result in issues considering the collaboration between the different software. The perfect scenario, I would say, is having all programs from the same producer, which of course will be hard when the collaboration between the different companies start.

However, the non-profit BuildingSMART alliance has come up with a solution for this, called IFC. This alliance is maybe the most important link to implementing BIM on a broader scale. But, is it perfect?

According to responses on different forums, there are a lot of downsides. The users are reporting data loss and have opinions such as IFC never will be as good, or have the possibilities that the native software have from which it was created.\(^\text{16}\)

(McPhee, 2013) Describes further that:

"IFC doesn't seem to capture all the functionality of BIM authoring softwares. For example it contains size dimensions, but doesn't know which geometric entities these dimensions control. So it can't transfer working parametric objects.(...) IFC is pretty much useless for As-Built BIM that will be used as a resource for future changes to a building. As an exchange format IFC can't be directly edited. And most data that handles the original authoring software functionality has been lost in the exchange. So at best IFC can only be used as a static background in an authoring software with editing capability restricted to deleting parts."

However, he claims that the thing IFC is useful at the time of writing, as an analysis tools, in facilities management and for coordination.

The analysis tools usually only requires the structural parts, and the thermal analysis tools only need spaces zones and envelope data.

From Facilities Management’s point of view, it is maybe what they need, and nothing more. One would not want the users to be able to accidentally move object, which is not possible after an IFC export. But again, if one would have to make changes to object, it is useless he says.

The coordination tools being software that are able to do clash detections and they only require what is already made and do not need to do any editing.

\(^\text{16}\) (McPhee, 2013)
So, how are we able to implement this, if the programmes are not collaborating at a true scale?

### 3.2 Autodesk

There are a lot of different solutions from different vendors out there, like ArchiCAD, and Tekla, which are very good BIM programs. There are pros and cons with them all, and I think this is a matter of likability and certain features that one prefer. With this said, I will focus on Autodesk solutions, which are the ones I am used to, and know of.

Autodesk has come up with their solution to the problem, with making software for every stage in a buildings lifetime:

- Autodesk Revit
- Autodesk Vasari (Beta)
- Autodesk Navisworks
- Autodesk 360 Tools
  - BIM 360 Field
  - BIM 360 Glue
  - Energy analysis for Revit
  - Green Building Studio
  - Structural Analysis for Revit
  - PLM 360

And more. These tools gives a project group the ability to make the whole building, from the brief design, with installations and structural parts ready for analysis by using Revit (Mass modelling, Structural parts, MEP); Vasari (solar and wind study). Also implementing Microsoft Projects timetable, and i.e. Sigma for costing of the building process by using Navisworks.

The BIM 360 Field and 360 Glue is tools that can be used to document the building process and perform clash detection linking it to Navisworks cloud service.

The sustainability of the building can be managed by the Green Building Studio which performs energy and water analysis for the building design. The PLM 360 manages the product lifecycle. ¹⁷

I want to go deeper into some of the Autodesk software’s that I think will play a major role to BIM in the construction process, which is the stage that maybe is to far behind when it comes to BIM.

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¹⁷ (Autodesk, 2014)
3.2.1 Autodesk BIM 360 Field and Glue

This is a tool meant to help utilize the BIM model at the site, during the construction. Also called Field data management. With this tool, one is able to go out to the site, with a handheld device for example an iPad, and have all the data of the project at hand. If for example there is a quality or health & safety issue at site, one can easily capture the information at once, providing pictures to clarify better, and the current position in the model. Once the note is made, it can be pointed to the individual for interest, and that person will get a notification.18

This correspondingly uploads to the BIM model in Navisworks and BIM 360 Field website, where the users can simply view statistics and manage all the tasks.

The 360 Glue includes more visualisations compared to 360 Field. This is more an inspection tool, still able to collaborate in the same way. While here you have the whole model at your fingers, out at site. With the ability to take measurements, hide ceilings to view the technical installations, and get distances between two elements.19

As of now, I will say that Autodesk has a good “total-solution” when it comes to the software of implementing BIM, and that it would make the implementation a lot easier to the industry if everyone was using their solution. This is, and will never be the case, so there has to be changes and therefore I think it is worth supporting BuildingSMART has started, with the IFC.

3.3 BIM and Web-based solutions

A company called Aconex is providing an IFC based “total-solution” providing the same collaboration tools as Autodesk, but without all the software. It is a web-based solution which every participants of the project upload documents and can collaborate through this website alone. For the modellers using Autodesk Revit, there is a plugin that simply uploads the model, and all its 2D drawings for the workers to the site.20

Their solution for the communication at site is pretty much the same as Autodesk’s, with the mobile app21 and additionally a Microsoft Outlook add-on22 which is a very common Email and schedule solution in most companies. They also have a solution for

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18 (Autodesk, Overview of Field Management with Autodesk BIM 360 Field, 2013)
19 (Autodesk, BIM 360 Glue mobile app - April 2013 update, 2013)
20 (Aconex, 2014)
21 (Aconex, 2014)
22 (Aconex, 2014)
the operation and maintenance manuals at the same place, which makes it convenient at the project, however there are better and easier operating solutions for this, in my opinion.

3.4 OpenBIM

The OpenBIM initiative was started by Graphisoft and Tekla, and is meant to be a: “universal approach to the collaborative design, realization, and operation of buildings based on open standards and workflows” (Graphisoft, 2014)

Without going too much into details, the key words are: System independence, integrity and ownership of BIM project data, and workflow transparency. This means that all the collaborating trades can join in with the software they are used to work with, not having to be taught any new. Since some trades need to keep ownership of the data they provide, there are solutions for this as well. The parallel data structure is being developed and coordinated with the use of open collaboration structures (Graphisoft, 2014)

It also require the programme vendors to use IFC as a common standard, which again strengthen the thought of supporting it.

OpenBIM is a really good method of implementing BIM to the construction industry because of its open-mindedness, and collaboration, and will be one of the keys in the coming years.

4 Why Renovate Old Buildings?

The European Union has a goal of renovating all old building masses by 2050.

Their reason for the ambitious goal, is that 40% of EU’s energy consumption are from existing, poor performance buildings. It is also one of the most significant sources of greenhouse emissions (36% in the EU).23

In another report, it is stated that by refurbishing the existing buildings throughout Europe, there will be additional co-benefits:

“**In addition to the energy savings that renovation of the existing buildings stock will bring, there are a range of co-benefits, which can also be harvested. By reducing energy consumption and focusing on indoor climate issues when renovating, co-benefits can be achieved such as reduced outlay on government subsidies, and improved health due to less air pollution and a better indoor**

23 (THINK, 2012)
This gives us good reasons of why to renovate, but we need to make the renovation sustainable, with good ideas of how to adapt to future needs, and changes.

LCA helps us analyse the whole building through its lifetime, to get an idea of what we are actually applying to our building; like how the wooden façade is transported, where in the world it comes from, Is it a type of material that is environment friendly, and if it will last the estimated lifetime of the building.

The function of the building is also very important; will it be easy to operate and maintain, will it be logical and easy for the people to use the building at a daily basis?

My opinion is that if we do not use this tool to make the renovation “smart”, the building loose its value, and will not be sustainable. This again will maybe lead to an earlier demolition, or a sooner than need 2nd refurbishment. In other words, an unwise renovation.

This is also something that applies to new build. So that the need of renovating maybe will not come so soon in the future.

5 The challenges and the benefits of implementing BIM and IPD

In the following chapter, I am going to guide the reader through what challenges, and what benefits one will have by implementing BIM and IPD. I will then suggest what I think is the key to full implementation, and what services that could be presented in Norway in the future.

24 (Copenhagen Economics, 2012)
5.1 BIM and IPD in a Refurbishment Project in Norway

If we look at a typical construction project today, there are several different participants and this is somewhat the type of organization table:

![Hierarchy of a typical construction project group](image)

The issue if you would want to implement for example a BIM model into this can be the ownership of the data. Every participant has their role in the model, and everyone has the right/need to protect their work by laws, and copyrights. There need to be a different way of how to collaborate, which I will get back to later.

Another issue that is stated in a report by (Miner, 2007), is who will control the model, and the data that is put in? Taking responsibility for everything that is put in, and making sure that it is the right information means a great deal of risk. He further claims that implementing this data takes more time, and therefore is a new cost for the design process, and the administration process.

Today’s competence in the field is yet another issue regarding the level of implementation. Though a report (McGraw-Hill, 2012) states that 36% of the Western Europe countries have adopted BIM, is the question: to what level? A lot of companies claims to have implemented BIM, but for some this means having a 3D model made in a BIM program, and that’s it. BIM needs to be seen as a process, not only the model itself.

We also need to address, that to implement BIM and IPD, there has to be enough people that know what this is, and how to use it to its fully extent; the professional
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individuals. They need to be able to assist and maybe lead their co-workers, so that everyone knows what this is, and how to use it in the projects.

There is also a saying that the company needs a respectable economy to do so. The key persons, the training, the software, and the “try and fail” period, can be expensive. They do also need to rely on the other participants in the projects to have accomplished this implementation, which not always is the case.

One of the big pitfalls with implementation, is that the process for the company starting it, until it is well known (to that current day’s standards), will be expensive and there will be a lot of complications. Therefore, the importance of keeping evolving and learning to take advantage from it, is crucial to make it productive and economical over time.

5.1.1 Better Planning and collaboration

As stated earlier, the regular flow chart is hard to execute when using BIM and IPD because of the ownership of the data, and the control of the model. This means that there need to be a whole new way of approaching the projects. Every participant needs to come in earlier to address their opinions. It needs to be a collaboration from the start.

When every participant shares information and eliminates the “ownership” of their work, there will be a better workflow and the process will be faster. However, this can
result in work getting harvested in a cannibalistic manner. This should ease through time, but as of now, there is room for remuneration to prevent this.

This strategy also helps finding the issues and crashes, earlier in the project. The model helps us discover what collides with the use of 3D, while IPD gives us more people at the right time and with expertise to discover them.

5.1.2 Reducing Double Entry Work

One of the keys to bring everyone in at the start, is to share the model. If every trade were to make their own model, there will be a lot of unnecessary work. This is of course something that relies on a common file format, like the IFC; or the use of the same platform.

5.1.3 Better Instructions at the Building Site

At a construction site, the builders get handed out 2D paper drawings which tells them where the structure they are about to put up should be from a two dimensional point of view. This drawing only includes that particular trade due to readability, so that if any other trade had some work in that particular area and their operations collide, or the objects the professions want to assemble would crash; This would need to be addressed at the regularly site meetings; which costs us loss of time because of hours spent on communication and decision-making in finding a solution.

What I am trying to explain is; today there are too many of these collisions which gets addressed at the site during the construction works, and not in the planning where it should have been. This gives higher economically consequences.

However, with BIM and the 3D model there are possibilities.

While these issues and solutions mentioned above are general to a construction project independent of that it is a new built or a renovation, there are more things to be mentioned when it comes to the refurbishment project.

Figure 6: Workflow chart explaining BIM process, compared to regular work process. (The MacLeamy curve)
5.2 The Refurbishment Project - additional challenges

At first, the owner will bring in different contractors for a competition and there will be a survey of the building and an introduction to what the owner wants.

The survey of an existing building is not always that easy. In very few cases, the building is stripped down to its structural parts. This is due to the owner and the clients need of income as long as possible, or even during the construction works in some cases.

This leads to a lot of insecurity regarding the calculation of prices, and planning of the time schedule.

The following text, I reference to direct conversation with AF Gruppen (AF Byggfornyelse) and an article in the Norwegian magazine “Teknisk Ukeblad” (Seehusen, 2014)

In Norway, there is a new type of collaboration currently emerging. This is called “sammispilskontrakt” (coordinating contract directly translated) and it has many similarities with IPD. Also here, it seems to be some challenges regarding the ownership of the model and with the sharing of information. Additionally the contractors seem to experience that they have the risk of being terminated from the project before the agreement of the final price has been worked out. The contractors also claim that at the projects they are to collaborate with the government owners, they have a problem with executing the early collaboration, which they claim to be the best result for the owner and contractor regarding risk and quality.

The Article also claims that the Norwegian standardization body: Norsk Standard (NS) is currently working on a solution to make this type of collaboration more concrete.

If this gets sorted out, and the early collaboration can be utilized, another challenge emerges. None of the contractor competitors would want to pay for a 3D scan of the building (which would make a 3D model importable to the editing BIM software) at this point, unless they had a binding contract to the project. And probably they would want to split this cost with the owner, or have them pay for it. But then again, would the owner take this cost? At project Paleet in Oslo, the contractor recommended at the start of the project, that they paid for a 3D scan of the structure, because of its complicity. That did not happen before 1/3 way of the project, when they met so many challenges with the drawings, that they needed make the scan.

I want to address what could have been done in this situation, with showing an example from Australia.

A company named North Surveys provides building surveys with the use of 3D Laser scanning and 3D mobile scanning. In a video they reference to one of their clients once
asked for a survey of a three storey hospital they wanted to renovate, and that they needed an “end product” to hand over to the designers and the engineers so that they could begin designing the building. After some discussion, they convinced the owner, to use the 3D scanning together with a regular survey, and to use Revit as a base for BIM. The scanning and the surveying took approximately 4 days to complete, due to the building being still in use, and the creation of the BIM model was completed in 2 days. While the model was in creation they provided 2D pdfs and a true views (True views are virtual walkthroughs of the whole building with the ability to take out measurements) to the architects, so they could start the design job without having to go to the site. When the model was done, it was shared so that their work could easier continue.25

This is an example of what can easily be done to speed up, and quality assure the surveying process this early. I will also attach a paper regarding HOKs refurbishment of Autodesk’s gallery and offices in San Francisco “One Market Street” as appendix 1, which was a refurbishment using 3D scanning.

My recommendation will be to convince the building owners that this is a highly recommended way to approach a renovation, regarding cost and time throughout the whole process, and even for their operational use after the work is finished.

5.3 Pushing “BIGBIM” to the Real Estate Owners

What is BIG BIM?

“BIG BIM utilises and develops the data from validation of the project through to operation of the facility, optimising performance at every stage. The approach challenges established roles and procurement approaches adopted across the construction industry, instead relying on integration of processes and lean thinking. BIG BIM is not only a technological advancement, it is also a cultural one.”26

How can this benefit the real estate owners?

A Norwegian company named Bimsync, provides a solution for the real estate owner, which give them the possibility to log into an account on their web browser, select the building of interest and then explore their building in full 3D. From here, they can get all the information that was put into a certain object when it was modelled. If they need to change a door, they can select the door in the model and get all its

25 (NorthSurveys, 2013)
26 (_Spacegroup, 2014)
information, including the producer details.\(^{27}\) To have a BIM model will benefit the real estate owners by helping the maintenance and operation of the building.

Further, this could help not only the single owners, but also larger areas, the city, and the country. Yes, this is BIG thinking (Big Data) but I think it is important to address this opportunity further.

“We should be dealing with places, not with buildings.” (Rogers, 2014)

Imagine being a real estate owner that soon needs to renew one of their buildings. They start the process with the contractors and the architects, and soon want to apply for a building permission. When they do, this information is saved together with all other information about every other facility in the same area, and the city.

But, what if this information could get there earlier? And there could be a bigger plan for this?

If there was a global gathering of the information in all existing buildings in a city, this could help us not only to renew the buildings, but also the bigger areas. This would help the efficiency, economy, and the sustainability of all the real estate owners, and the municipality. It would be comparable with what we are doing with new built, and the building smarter solutions for not only one building, but a whole community or city.

Not only would this benefit the owners, but like earlier mentioned, this would help the construction companies to get earlier knowledge of what they are dealing with, by having a model ready.

At a seminar in Norway, Statsbygg are describing, as a real estate owner, the importance of having a BIM model of their buildings. They are not only using it to make maintenance and operation easier, but they want bring the opportunities further, by making it possible for the users of their buildings to take advantages of it too. They want to make the users able to use their mobile phone as a guide with information through the building, and the information differs depending on what type of service one wishes for.

During this seminar Statsbygg shows that they together with Forsvarsbygg, Helse Sør-Øst and Helse Midt-Norge, they have signed a collaboration that states the following:

“We consider predictability as a major value in our business development plan, and we want to give the building industry a clear understanding of our intentions.”

\(^{27}\) (Bimsync, 2014)
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Within 1st of July 2016 we will demand that all software used in our projects in order to create, edit, store or process data from the building information model, shall support complete interoperability, by communication and sharing building information based on OpenBIM. The software used in our projects shall be certified to export, link and import all information in the latest official version of open international formats like IFC (ISO 16739) and BuildingSMART International official IDMs and model view definitions.”

This is the biggest real estate owners in Norway, demanding the AEC (Architecture, Engineering and Construction) industry to implement BIM.

5.4 DiBK – Direktoratet for Byggkvalitet (The Norwegian Building Authority)

DiBK is a supervisor authority for products that are to be used in buildings. They also assess if a certain firm is qualified for “central approval” in Norway, as well they act as a centre of expertise for the municipalities and advisor for the Department of Modernization. 29

5.4.1 ByggSøk

The first version of their web-based building application (Byggsøk) was launched July 1st, 2003. The current version was launched on January 7th, 2013. Byggsøk is now divided into three separate solutions:

“ByggSøk information works as an information provider for users. This is a one-way information channel.

ByggSøk planning is a web-application developed to serve the application for zoning plan proposals (Jotne EPM Technology, 2012). The application enables electronic filling in and submission of zoning proposals over the Internet, in accordance with the Planning and Building Act (PBL). The ByggSøk planning initiative was shelved in 2010.

ByggSøk building is a web application developed for applications for building permits. The application enables electronic filling in and submission of building applications over the Internet, in accordance with the Planning and Building Act

28 (Statsbygg, 2014)

29 (The Norwegian Building Authority, 2014)
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(PBL). The applicant is guided through the application process and if necessary receives help, and the application verifies that all fields in the form are filled in before submission. Finished applications are submitted by email with digital, static attachments. Applications are processed in the same way as traditional applications. Use of ByggSøk is free of charge. It is possible for local authorities to integrate ByggSøk with existing GIS solutions for maps, estate information, neighbours, etc. ByggSøk is defined as a semi-automatic solution. ByggSøk will contribute to standardization, simplification and streamlining of the planning and building process.  

With ByggSøk, The Norwegian Building Authority have actually started the digitalization of the building application many years ago. This is very convenient when it comes to implementing BIM to the application, because they already have a well-known and well used digital registration. They are also currently conducting a pilot project in collaboration with Catena and ICE-Consult:

“Automated compliance-checking – checking BIM models against Norwegian standards:

The aim of the projects is to develop a solution for automated compliance-checking against EN 15978 for open BIM. The pilot should be scalable, i.e. be applicable to other standards. Easier use of standards will streamline the construction process and unsure the use of best practices.”

What this actually means for a real estate owner is that one can upload a BIM model to a website, and then it get checked against general regulations, the site specific regulations and the building codes, and if it meet the requirements of the current standards form “Norsk Standard (NS)”

(Rooth, 2014) Furthermore states in a presentation that the things that are needed to get to the stage where the attachment of an application can be computer analysed with the use of BIM and GIS, just to mention some: Geographical information, property information, zoning plan information from GIS systems; computer analyses of information and computer readable building codes and regulations.

These statements actually further back-up why real-estate owners should be brought more and earlier into the BIM implementation which I have stated earlier in this report.

30 (Holte Consulting AS, 2014)
31 (Holte Consulting AS, 2014)
5.4.2 ByggNett

However, the presentation above mentioned is some years old, and DiBK has been working on a new and more ambitious project called ByggNett. It was introduced in a parliamentary report (nr. 28, 2011-2012), and was called “et Altinn for Byggesektoren”. Translated “an Altinn for the building industry” (Altinn is an institution providing a link between the private person/company, to the government in Norway, and provides all digital solutions like appliances and taxes). This and the following text is a reference to

The intention of this project is to offer services for institutions/individuals that has interest in the whole lifespan of the building(s) – from the idea face, application, approval, construction, operational and maintenance, renewal, and until its liquidation. A business model report erected (referred to above, and below) by (Holte Consulting and Bekk Management Consulting, 2014) on behalf of DiBK are looking at four interconnected solutions for the future development of ByggNett.

The four solutions are stated in the report researching the future of ByggNett, but simplified:

1. Effective procedures for appliance
   
   ByggSøk is still in use as a part of ByggNett, but it is more interconnected between municipalities. BIM standardization has come so far, that the government sees code checking as a natural step further.

2. Digital procedures for appliance
   
   A business plan would be that this stage allows electronic application for about 50% of the total applications. Testing of the application is possible before the hand-in. The application can be uploaded and answered in seconds. This will now make Norway one of the first countries in the world performing this.

3. Boost of the industry
   
   Intentions to raise the quality and knowledge of the AEC industry in Norway. As ByggNett is still evolving, there will be powerful measures to digitalize the industry, for a limited period of time, i.e. teaching of the employees in the government, part-financing the software investments for companies, establishment of BIM and ByggNett as a part of university educations for the building industry, financing research to the field, like MSc. And PhD. This will be addressed as a “game changer”

4. National Infrastructure The boosting of the industry is now at its end, but investing in the platform will “never” stop. ByggNet is now a stable, mature and
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a critical service for every target group. In practice, this is now a service that is nearly impossible to walk around.

*Figure 7: The 4 suggested development structures for ByggNett, put together as stages. (Holte Consulting and Bekk Management Consulting, 2014)*

This is has an implementation period from 2013 to around 2020. I would say that the technology is already here for almost every stage, but experience from throughout the world shows that innovation, development and change should be implemented over time. This ensures that all involved parts manage to build necessary competence and understanding between the stages.

Further I want to address the importance of the above underlined, and that this should be implemented sooner. I will also go more into the different educations in Norway later.

In my opinion this is one of the best strategies to implementation of BIM there is, at the moment. It addresses the lifespan of the building(s), in addition to carefully include all its participants during the buildings lifecycle. If this gets factual, it will definitely mark the industry with better quality and better efficiency in the years to come.
6  My Experience in a Refurbishment Project, not using BIM

At the 6.th Semester of my BATCM education, I had an internship period at a constructing company called AF Gruppen, in its department AF Byggefornyelse (Urban Refurbishment) as a part of the education to get an experience of how the construction industry was. The department of the company mainly focused on Refurbishment projects. The company in its entirety, is the 3rd biggest construction company in Norway, and have started to implement BIM. However, it was not executed at this project, due to the owners wish.

6.1  The Project

The project is a refurbishment of a shopping mall called Paleet. It is located in the centre of Oslo, Norway in a one of the main streets of the city called Karl Johan’s Gate, which is leading towards the Kings castle.

The building is a mix of different periods of buildings, with the two main parts being from 1980s and the 1840s. While there are some stores that are still open at the street level of the building, it is a total renovation. However there is a special feature of a covering, over an old restaurant that is worthy of preservation, and all this makes the refurbishment even more complex.

Stated earlier in this paper, there was no 3D scan of the whole building, and there was a lot of mistakes in the drawings that needed to be updated during the building period.

6.2  The Challenges

6.2.1  Drawings and clashes

The first thing I was noticed was at a “clash detecting meeting” at the building site, When they suddenly brought up the plotter drawings of the different trades at a big table, and started working. This was not really what I was expecting it to be. And to be able to detect crashes with using 2D paper drawings I think is a bit hard. Which it proved to be later on in the project.

What occurred later in the project – some weeks before start-up of the works – was a problem regarding the height of the different technical trades several places. As there was one company responsible for HVAC, and one for the electrical, two of the three different trade's participants was combined into one. This should have made the collaboration and clash detection easier. Nonetheless, the clash was detected and they found a solution, for now.
Later on, a week before start-up of the ceiling works done by the carpenters, a bigger issue was found. The mounting rail for the ceiling was crashing with the connectors for the sprinkler system, which was all over the 1st floor. This took a lot of effort, first finding the mistake causing this (which was different datum points for the heights, for the different trades, due to this being an old building with a lot of bias throughout) then fixing the problem, which meant involving the architect, all the different technical trades, and the owner.

We used weeks cracking this problem, and when it was unravelled, the ground floor was next. Here we had more space over the ceiling, and everyone was pretty sure from the start, that this was taken into consideration. It was not, and we had to make a case of this also here.

In addition, when the carpenters were about to start mounting, the technical trades were not ready for this to be closed. 10% of the ceiling was covered, and there had to be a pause.

I am 100% sure the problems above mentioned could all be extinct with a BIM model at place, with the right persons operating it, and with the perceptive quality assurance at site. There are also huge possibilities in how to manage all the trades in a scheduler’s point of view, if using a tool that could transform the schedule into a visual preview; a tool like Autodesk Navisworks.

### 6.2.2 Communication at the Site

There was a mayor part of foreign workers at the site, which now a days is pretty common at the big projects in Norway. This creates a weak link, when it comes to understanding each other. As an example if you want to give an instruction, they tend to say yes, like they have understood it and then they go do something totally different. I think this roots from our cultural differences. In the Eastern Europe there are more strict rules, and one does not want to make a mistake. This can lead to a lot of mistakes and redo’s at the site.

Another issue, is all the links between us as a contractor, and the workers at the site. In the start of the project, there was no construction manager from our subcontractor at the construction site, which actually was a requirement in the contract. This lead to me doing work for the subcontractor. We stated early on that this needed to change, and they had to have one person to lead the workers at site at any given time.

As we were the main contractor, and hired a subcontractor, which again hired their subcontractor to do the actual work this lead to communication problems. Before they had their leader at site, and the workers had a question, they were usually asking me...
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(as the one that was following up the carpentry trade). I then had to go up to the office, send a mail to the project leader with the concern in question. Then he had to come with the answer, send this to their subcontractor, which again had to report to the site.

All of this creates so many communicational links, and each of these links could lose necessary information for the workers task, and this can go on and on.

Concerning the communication of the project group from AF Gruppen, this was in my opinion good but had its issues too, like every other project. There is always something that “slips between two stools”, even for the most experienced and skilled in the project. For example, one of my oldest colleagues was writing down almost every single detail he came across during the day in his notebook, but even then, it is easy to forget.

During the day, most of the people use hand-written books to take notes, and make their log. But the company does not benefit from everyone writing their own notes on the piece of paper, they benefit from having a database with all the information and knowledge shared. They actually did have this database too, but it was hardly used. The question I would raise after this is then, how does one implement BIM, when the people that are going to use this actually still have the issue with digitalizing simple notes?

6.2.3 Proficiency of the Trade

There was also a lot of mistakes made by the carpentry trade at the site, which made us raise questions to their experience and certifications in the trade.

Because there were two companies that had carpenters at site being the subcontractor, to our subcontractor again (sub – subcontractor), we needed to take up our concerns with the company we had a contract with. To explain this short, we had 4 meetings concerning quality and progress of the work, and they did not meet our wishes even then.

Worth mentioning was also a project leader from the subcontracting company that seemed to not have any technical background. That led to a lot of unnecessary descriptions from both me, and their workers at site.

As none of the workers at site was of Norwegian origin, we had to ask them for their trade certificate from their home country. Some of them had, and some of them did not. However, the quality was still bad, and partly the reason for this, roots in the different building traditions and regulations in our countries. Nevertheless the main reason for all the faults are to me unknown.
6.3 The Consequences

By having this many problems in one of the larger trades at the building site, did cause some problems not only for this particular works, but also for everyone else.

There was a huge delay on the carpentry works, and since they very often had to correct their mistakes, they got even further behind on schedule, without having a plan for how to regain lost time. As the carpenters are responsible for putting up the new interior walls, this of course delayed the electrician and the plumber that was supposed to cross with their equipment. This shows the importance of correct scheduling and the collaboration of the project for everyone that are attending. Of course, there was communication through site meetings every week, but the problems usually tend to come when it fits the least.

The consequences of the works above mentioned, tend to be loss of time, cost and unnecessary deliberation. In time, these kind of challenges I think leads to poor collaboration between the different project contributors due to bad atmosphere.

What I think was very good, and one of the most important effects about my stay at AF Gruppen, was the good atmosphere internally in the project group. We were 11 participants which included mostly younger people, but still we had the solid and well experienced key individuals as well. Fresh thinking by young people is important, but those people require decent assistance from the more experienced and older.

6.4 How can this project benefit from using BIM and IPD

I want to look at this from two angles: one that I think would be possible as the situation was at that time, and with the same contractors, architects, and owners. And from an approach that shows all the possibilities of how this could have been done with the full implementation.

6.4.1 Realistic point of view

If I would be looking at the project, with the same participants, executing BIM would be possible to a certain extent. The architect claimed to have ArchiCAD as one of their BIM tools and the HVAC coordinator did actually have a BIM model of the sprinkler and ventilation systems. However, there was some that did not have that much competence about it too, like the carpenter firms. The electricians I am not quite sure of, but their workers showed great interest in using IT tools at the site that could help their work easier.
So, with an assumption that the electrician were able to manage and use a BIM model, the model could have been made and used for the planning, costing and as a handover to the owner after the works was done. Additionally the AR could have been used throughout the construction and operation, helping the workers to compare reality against the BIM model.

All this is of course dependent on a 3D scanning of the building, due to the complexity stated earlier in the report.

The stumbling point of the BIM usage, would have been when the works started. AF as the main contractor, did not (that I know of) have any tools (handheld devices/smartphones with proper apps) able to use the BIM model at site, and for site collaboration. Yet the BIM model would have been helpful at many cases as a hub for information, and drawings.

Ultimately, the model could have been handed over to the owner, and they could have used it for the operation of the building.

6.4.2 The way it should be

A perfect scenario, would be that the owner had a BIM model ready, after a 3D scanning, which they would have used for the operation of the building until the projects start. This would have led to an easier organising of the rig, and the locking of the parts of the building that were not included in the renovation. There would be easier to look up information about the existing building as well.

Then there could have been an early collaboration with all the participants, including the operators of the building, which then again would have led to earlier detection of issues. The BIM model would have been brought to site, with software and tablets for the persons managing the production at site, with easy collaboration through cloud based software, preventing any information loss. With the 3D tools, there would also be easier to discover the unforeseen issues as well, and if trades would clash at certain operations, or places. There would be easy to track changes throughout the construction with the tablets, or even more advanced, the 3D scanning in progress.

With this information there would be easy to get statistics connecting to the company’s server, which again could help choosing i.e. subcontractors for later projects.

The owner would get the new BIM model at the delivery, and this would be uploaded to Byggsøk’s database, for future development of city plans. The model would reflect the ‘as-built’ project. Moreover the maintenance personnel could find EVAC systems just by using AR and the BIM model at the certain place in the building, which would ease their maintenance work drastically.
7 The Key to Implementation in Norway

To be able to implement new technology in a company and an industry, people need to know what it is, and get proper guidance. I think one of the mayor issues to implement BIM today, are the people and the knowledge. As stated earlier the technology is already here, but we do not have that many of the key persons that know how to use it appropriately.

What do we do about this?

7.1 Education

Today there are about 4 institutions in Norway, teaching BIM. The first one was Fagskolen i Oslo, which in 2008 started the education: BIM-Tekniker or “BIM-Technician”, with one class of around 30 students. The architecture and engineering educations only have a certain possibility for teaching BIM, due to all the other subjects, which mean they will never be able to conduct BIM in the matter it needs. This means that educations concentrating mainly on BIM, is the solution that is needed for the future.

In UK, Canada, Denmark, South Africa and Ireland, there are educations teaching Architectural Technologists. This education is focusing a lot on BIM and BIM management, and it is a Bachelor degree with 210 ECTS points (can be compared with BSc (Hons)).

I think an education like this is needed in Norway too, to keep up with the current and growing demand for the knowledge of BIM.

7.2 Changing Human Behaviour

There is also a need for the people that are currently working in the companies, to understand what this is, and what the future will bring. Today there are a lot of doubts regarding the economic advantages of using BIM, but I tend to think this is because they are stuck in the middle of their implementation.

As I mentioned earlier, there is still hand-written documentation of the daily tasks. Why isn’t this digitalized? For some it is, but for the people that have been in the industry for many years, paper is still the preferred method. These persons will probably not be

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32 (Copenhagen School of Design and Technology, 2014)
the greatest supporters of BIM either, so the introduction should be carefully introduced.

However, support from the government to erect this digitalization (like the ByggNett project suggest) would be highly appreciated by the companies throughout the industry

7.3 CF Møller’s (Danish Architecture Company) way of implementing BIM and IPD

As a part of this report I chose to do an interview with somebody that have the knowledge and experience of the implementation of BIM and IPD. With the help from my special advisor James, I got in contact with Simon Olafsson at CF Møller.

CF Møller was established in 1924, and is one of Scandinavia´s oldest architecture companies. They started their BIM implementation back in 2008, with two projects. One of them was “A-Hus” hospital in Norway, Oslo.

Today, they claim to be at their “finishing” stage of the implementation, and as of 1st January, 2014, they are closing down the use of AutoCAD, to just be using Revit. They are even working on using Revit for their mass modelling (creating models with less constrains and be able to form advanced shapes), and this is something architects are usually afraid of, because Revit is more advanced in use, compared to a software like Rhino. Simon further explained that Revit Vasari was a type of “Revit light”, which again was another solution for making masses.

Furthermore, with their implementation of BIM, they are aiming for one less person per project, for every 5th person. (5 persons without BIM at a project = 4 persons with BIM) The top leaders in CF Møller also believes in BIM and IPD, and therefore they know the first projects will be showing red numbers at the end, Simon also says. This is something Autodesk show in the figure 8.

33 (CF Møller, 2014)
The most important thing CF Møller has done, in my opinion, is their engagement to this implementation. They have included lectures about Revit and BIM, at a daily basis. So the employers can take courses during the working hours, while still getting paid. They even have workshops every 3\textsuperscript{rd} week, during the whole year that is mandatory.

They also have employers at every level in the organization chart, which has responsibility of the BIM process, even one of the partners. Their BIM organization chart look somehow like shown in figure 9:

![BIM organization chart](image)

*Figure 9: BIM organization chart based on what was shown to me at the meeting with CF Møller.*
8 Conclusion

It is safe to say, that the implementation of BIM and IPD will drastically help us produce buildings better and faster in the future. The biggest reason for the doubts of implementation and slowly integration is knowledge, money and collaboration issues. In my opinion there is little reason to explain what we can save after the implementation is done because there are so many examples out there of how processes can be done so much easier, so much faster and of better quality. The right question to ask is actually how the companies can get this knowledge through internally in the fastest and most efficient way to save money by not falling into an endless implementation phase, which will definitely not bring any reimbursements.

The main focus of the industry should be how to manage a model. The right computer software is of course important, but even more significant is the collaboration between the different software solutions. BIM does not gain from having different vendors, if they are using different file formats and are not cooperating.

Therefore the discussion of what BuildingSMART is working on with the IFC, is worth having. There are many disadvantages of exporting to IFC, such as: loss of information, no possibilities to edit it in another editing program (i.e. Revit/ArchiCAD). But it is as of now the best solution for collaboration between all the “non-editing” software’s and these tools are the most important after the model is made.

The trades also need to find out and research how the model can be of use to them. Through the report I find it not only useful for a designer and the contractors during the planning to experience how the building will perform, but also the contractors at the site; to keep a track of the schedule and as a tool to help the quality assurance and the health and safety. Furthermore the owner will be able to use this for the operational use. With new and modern technologies they can implement mobile applications for better user experience and of course further development of the structure. This is BIM, BAM, BOOM!

The biggest finding of what BIM is capable of in my opinion, is what the Norwegian building authority is working on with their project ByggNett. This is a key to help the industry with the implementation. Not only by what (Holte Consulting and Bekk Management Consulting, 2014) are suggesting, with the help of financing the implementation, but also by making it a simple task to apply for a building permit by uploading a BIM model and then seconds after getting an answer. This is only suggested futures for DiBk`s ByggNett, but I think this is the biggest contribution going on at the moment. This is because it has possibilities to further develop cities smarter with the gathering of all the BIM models. This makes BIM a tool for the buildings and the cities through their lifetime. This is expressed elegantly in the following quote:
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“We should be dealing with places, not buildings.” (Rogers, 2014)

We are just touching the surface of capabilities. Add more if possible

With referring back to my example in the introduction related to a refurbishment project. I will say that at the planning stage with the possibilities ByggNett and 3D scanning provides, then pushing the real estate owners to do this survey before they need to refurbish will make more sense. The survey that the contractors would do at the very beginning, could be done with the BIM model at site just comparing model with reality and then implementing the findings and conditions to the model.

“The pencil and computer are, if left to their own devices, equally dumb and only as good as the person driving them.”

- Sir Norman Foster
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Kaye Alexander looks at advanced contractual and modelling techniques on an HOK office refurbish

The £6 million remodelling of Autodesk's gallery and offices at the software company's San Francisco base - One Market Street - is HOK's first completed project using its new Integrated Project Design (IPD) contract. Underpinning the concept of IPD is the use of Business Information Modelling (BIM) and the incentive of shared profit.

Usually, the parties involved in an IPD contract comprise the architect, contractor and client. 'On this project, the architect's role in designing the office and gallery space/customer briefing centre was divided between HOK and Seattle and San Francisco-based Anderson Anderson Architecture, so a four-way variant was drawn up,' explains Archie Stephens, HOK vice-president.

IPD aims to achieve what the contract terms 'mutual success', where each party recognizes that its opportunity to succeed on the project is tied to the performance of the others. The parties will, the contract states, within the limits of their professional expertise and abilities, work together in a spirit of cooperation, collaboration and mutual respect. 'The budget for the project is structured in three layers: a pre-agreed direct expense element for project costs (design, construction and legal); a contingency layer for unforeseeable events; and an Incentive Compensation Layer (ICL). For Autodesk, the ICL was structured around the following principles:

- If the project costs come in under-budget, 50 per cent of the saving is added to the ICL
- If the project is over-budget, the excess comes out of the ICL until it is exhausted
- If the project is within schedule, £4,500 for each day won is added to the ICL
- If the project runs over schedule, £1,500 a day is deducted from the ICL.

These bonuses and penalties vary from project to project. Profit on the Autodesk contract was also subject to the team achieving project design targets for quality, innovation and sustainability (part of the brief stated that the building should achieve a LEED Platinum rating). These targets were set and assessed by an independent third party and the ICL could be adjusted by plus or minus 20 per cent accordingly.

Project management and implementation teams were set up, consisting of one member from each firm. All decisions had to be unanimous and there was no litigation clause in the contract.

A typical construction contract for a project like this would be at least two-and-a-half inches thick; ours was only half an inch thick, with single-sided printing,' says Sam Sparta, director of HOK buildingSMART.

'By defining the project clearly from the beginning, the client has little wriggle-room,' explains Mark Flax, HOK director of the San Francisco interiors group. But this
means that there are fewer construction change orders.’

The project was atypical implementation of IPD, because the decision to use the contract form was made late in the process and the budget that had already been set had to be increased. It was decided that no incentive compensation would be paid out for beating the budget or schedule, so all profit was based on achieving the design targets.

The IPD contract form is structured to take advantage of the interdisciplinary practice centred around BIM. The use of BIM has been mandatory for new projects at HOK since January 2006. HOK uses Autodesk Revit to manage the data. For the One Market Street job, the contractor, DPR Construction, had equal ownership and management responsibility for the BIM model alongside HOK and Anderson Anderson. DPR Construction had a BIM team working on site throughout the design and construction process and collaborated with the architect to import the Revit architecture model plus 28 additional system design models into Autodesk Navisworks, to perform clash detection and full co-ordination of all construction phases and details. A large-screen monitor and smart board were installed on the project site and used as a focus for design and construction discussion, detailing, and revision. This meant that accurate information was available to subcontractors for off-site fabrication, and the model could be queried for immediate availability of dimensions, details, and 3D imaging of project details that were not clearly available in the print documents.

All design targets were met, so, at the end of the project, an ICL pool of £467,000 was available, which was split between the parties according to their contribution: HOK (11 per cent), Anderson Anderson (23 per cent) and contractor DPR (66 per cent).

BIM proved especially useful in the design of the building’s ceiling projectors and mechanical and electrical infrastructure. See pages 34 and 36 for a study of these elements.

HOK’s BIM organisation chart, showing how information from specific models was co-ordinated

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Left Interior of the gallery at Autodesk’s One Market Street. BIM was built into all subcontracts
**CEILING PROJECTORS**

**Problem** How to install the gallery’s ceiling projectors and manufacture the stretched fabric ceiling boxes accurately off-site, so that the projected images were correctly positioned, without the need for adjustment once fitted.

**Solution** By using BIM, the projected light paths from the ceiling projectors in relation to the ceiling boxes could be verified in the model before being made and installed. Some of the ceiling boxes required precisely located cut-outs in their sides to allow the projected image to display correctly. The BIM model helped to determine the exact sizes and locations of the cut-outs prior to fabrication of the boxes.
Problem In order to meet sustainability targets, the team wanted to re-use as much of the existing mechanical, electrical, plumbing and fire protection systems as possible. In order to do this, while including as much prefabrication as possible, an accurate virtual representation of these systems was required for the team to evaluate what could be re-used and to ensure that newly prefabricated elements aligned. The architectural and structural ‘as built’ plans were inaccurate, and no equivalent servicing drawings existed. Accuracy of information was especially important, but difficult to achieve, because the existing space lies within a complex of three conjoined buildings — one of them on the National Register of Historic Places — owned and managed by two different firms, all of which contributed to the potential for confusion and diplomatic complications.

Solution Given the project constraints, 3D laser scanning was decided upon. DPR partnered with BIM specialist Optira to produce a laser point cloud, which was accurate to 0.2mm. An ‘as built model was created from this and imported into the BIM model to finalise the design documentation. It was also distributed to the appropriate subcontractors.

Above Plan of office and gallery space