

## Work in progress

### The use and adoption of Building Information Modelling in Sweden

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#### Abstract

Building Information Modelling (BIM) is defined as a software tool used to handle the construction process through design and planning, production along with operations and maintenance. BIM has been used as a new management tool in the construction industry during the last decade. There are however little research on investigating the use and adoption of BIM as a tool on a country level, instead main research on BIM focus on the technical aspects of BIM along with discussing how BIM is used in individual projects and within single organizations. This paper aims to provide a picture of the status of the use and adoption of BIM in Sweden. Through an in-depth interview study with main actor groups in the construction industry (technical engineering companies, architects, construction companies, clients/project owners) we find that basic BIM knowledge exists among construction actors and BIM is especially adopted in the design and planning phase, while BIM is less used in production and in operations. Higher level BIM is however limited to a few ‘extreme’ projects. The adoption of BIM is mainly driven by technical engineering and construction companies, while architects and clients are lagging behind adopting BIM.

*Keywords: Building information modelling (BIM); Construction industry; ICT; Projects; ARA*

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## Introduction

The construction sector is an important engine for the economic wellbeing in countries worldwide; it is estimated that the sector normally accounts for more than 10% of the national gross domestic product (Winch 2010). The construction sector is however not only economically important but also plays a key role in society by supplying a growing population with a built environment including well-working infrastructure, a vast variety of buildings, along with areas for recreation. While recognizing the construction sector as important for creating an economical and societal viable society there are challenges associated with achieving this. It has been noted that the construction sector underperforms and lag behind other sectors in exploiting new technologies, engage in innovation along with creating productivity (Egan 1998). Due to declining productivity and escalating costs there is a commonly held view that the sector needs new ways of organizing. New project delivery forms (e.g. partnering), process thinking (e.g. lean), standardization and industrialization (e.g. prefabrication) along with new coordination tools (e.g. Building Information Modelling, BIM) are proposed methods to achieve change in the construction sector.

Especially Building Information Modeling (BIM) has gained increased attention during recent years in contributing to change within the conservative construction sector. BIM has been defined as "*a set of interacting policies, processes and technologies generating a methodology to manage the essential building design and project data in digital format throughout the building's life-cycle*" (Succar 2009: 357). BIM is hence a software solution that can be used for managing information of any building object during its design and planning, production and maintenance. The benefits of BIM are diverging among construction scholars; there is however a general consensus among scholars that the use of BIM changes work practices in the sector (c.f. Sebastian 2011; Bryde et al. 2013). The use of BIM and the changes it evokes is intimately connected and has been studied previously (Linderoth 2010; Davies & Harty 2008; Won et al. 2013) Samulesson and Björk (2013) however point out that these studies tend to be rather isolated investigations among individuals, occasionally among single organizations along with investigations of single construction projects. Main bulk of studies thus ignores to investigate the wider use of BIM along with the changes it imposes among several actors in the sector and across projects.

The paper rests on the idea that any sector or market is constituted by several interdependent actors (individuals, companies, organizations, government agencies etc.) which together form a stable network of relationships (Håkansson et al. 2009). These relationships are established and developed since actors do not internally possess all resources and activities necessary to operate its business. Instead actors are forced to interact with other actors to access critical resources and activities. When sharing and combining resources and activities across organizational borders actors become interdependent of each other. Introducing an innovation, such as BIM, to a network will therefore cause changes and effects on the existing actors and their interdependent relationships (Van de Ven et al. 1999; Håkansson & Waluszewski 2007). With this in mind the paper aims at understanding how BIM is used and implemented among several actors in the Swedish construction sector and how this changes the construction sector. More specifically the following research questions are formulated as:

*RQ 1: How is BIM used and implemented among Swedish construction actors?*

*RQ 2: What effects are created due to the use of BIM in Sweden?*

The first research question relates to understand the decision among construction actors in engaging in BIM along with understanding how BIM is used among actors. Since the research project departs from an industrial network perspective the decision to use BIM is not always in the hands of the individual actor. Instead the decision can be imposed from several other actors in the network (Håkansson et al. 2009). Implementing the use of BIM is however associated with large costs such as BIM training and large investments in information systems. The network perspective however emphasize that neither the costs of innovations nor the benefits are equally distributed among the actors in the network (ibid). Hence how BIM is used among actors also related to understand how costs and benefits are distributed among construction actors.

The second question relates to understand how BIM as an innovation creates effects on actors and their associated resources and activities within the network (Boland et al. 2007; Håkansson et al. 2009). To exemplify, the use of BIM for production activities can have direct effects on how to plan and procure materials, which can create indirect effects on the sub-suppliers to adjust to new logistical routines. Hence BIM as an innovation may create innovative effects to resources and activities stretching outside of individual projects and individual organizations (Dubois and Gadde 2002).

## **Literature review and theoretical framework**

### *The use of BIM – creating socio-technical effects*

With the increase use of information technology in construction sectors world-wide BIM has become an increased researched topic among scholars (Succar 2009). Main part of BIM literature have however been focused at understanding the technical aspects of BIM (Cao et al. 2015), while research on the managerial and social aspects of BIM have been limited according to construction management scholars (Cao et al. 2015; Cao et al. 2014; Bryde et al. 2009; Forsythe et al. 2015; Succar & Kassem 2015).

BIM is a software tool which not only results in effects of technical character but to a large extent also changes social practices such as work flows, collaboration along with routines etc. Grilo and Jardim-Goncalves (2010) point out how BIM changes the collaboration among project stakeholders, while Sebastian (2010) emphasize that the use of BIM bring about new professional roles, such as model managers along with changing power relations among project actors. Olatunji (2011) raises the need for changing legal frameworks, new business models along with new procurement methods in order to achieve a greater diffusion of BIM. While Linderoth (2010) point out that any project actor has its own view on BIM and its potential use, which cause tensions among actors. Tensions between actors within single organizations are also highlighted as a hinder to use BIM within single construction projects according to Davis & Harty (2013). The scholars however emphasize the use of BIM as a result of interaction between both technological and human practices. In a similar manner Won et al. (2013) also conclude that the use of BIM is dependent on a combination of technical and social dimensions, however social dimensions was pointed out as even more

important than technical dimensions for diffusing the use of BIM within organizations. Succar & Kassem (2015) conclude that BIM imposes changes not only within single organizations but also across organizations and markets. According to Succar & Kassem (2015: 68) use of BIM can be characterized as a “complex adaptive system” constituted by a combination of social and technical elements.

### *Innovation in the fragmented and inter-organizational construction sector*

Scholars have emphasized the construction sector as a “special case” with its own characteristics that creates particular conditions for achieving innovation, such as BIM. To begin with main activities in the construction sector are taking place within time bound projects among a large variety of actors (Winch 2003; Dainty et al. 2001). For any project a new constellation of diverse project actors (such as clients, contractors, designers, suppliers and sub-suppliers etc.) need to be assembled to collectively deliver a particular project. As a consequence the construction sector can be characterized as a highly fragmented and inter-organizational setting (Slaughter 1993; Tennant and Fernie 2014).

Some scholars (Principe & Tell 2001; Ayas and Zenuik 2001; Scarbrough et al. 2004) see the project-environment in itself as a good base for problem solving and innovation, while other scholars (Miozzo & Dewick 2004; Grann & Salter 2002; Brady & Davies 2004; Seaden & Manseau 2001) describe the project environment as challenging for innovations to be diffused outside individual projects; to other projects or organizations. Havenvid et al. (2016) and Crespín-Mazet et al. (2015) show that innovation is taking place in construction, however innovations are incrementally developed throughout several construction projects involving reoccurring actor constellations. This shows that construction innovation not only relates to temporary project networks but also to permanent network of established actors (Dubois & Gadde 2002). A similar discussion can be found in Havenvid et al. (forthcoming 2016) who emphasize that construction client requirements’ of using particular innovations in individual projects result in interactive and innovative effects stretching both the project network and the more permanent network. This is related to what Boland et al. (2007) put forward when describing construction innovations as an “engine of innovation”, i.e. the use of an innovation creates innovative effects and changes throughout the network of actors. As a consequence Boland et al. (2007: 643) call for the need for a wider “ecological” perspective in capturing innovations and their interactive effects in the construction sector.

### *Understanding innovation and its use – the need for a network approach*

Against the discussion above, Boland et al. (2007) view innovations as dependent on interaction with other actors and organizations, a view that is shared among innovation scholars such as Rosenberg (1982), Van de Ven et al. (1999), Fagerberg (1995) and Uzzi (1997). Resources such as knowledge, projects and products can be exchanged, shared and combined through interaction between various actors. Several innovation scholars especially emphasize the users as important sources of innovations (Chesbrough 2003; von Hippel 1998; von Hippel 1976). But in order to understand innovation not only the users have to be taken into account, instead innovations need to be seen as related to a larger network of actors

(Powell 1990). Thus, innovation is the result of interaction between organizations and their environment; hence innovations are “co-produced” and/or “co-developed” (Srholec & Vespagen 2012; Van de Ven et al. 1999; Lundvall 1988). As a consequence in order for an innovation to be diffused and spread it need to be accepted and mobilized through a web of actors. Akrich et al. (2002: 203) emphasize this by describing innovation as: “*perpetually in search of allies. It must integrate itself into a network of actors who take it up, support it, diffuse it*”. By encounter different actors the innovation is shaped thorough “negotiation processes” among actors and their associated technical and social resources.

A similar interactive view on innovation can be found among researchers adhering to the Industrial Network Approach (INA). The research stream is based on the idea that industrial development happens through interaction between actors such as suppliers and customers. Through interaction networks of relationships are established and developed which constitutes the “market” (Håkansson et al., 2009). It is also through these interaction processes that innovations are developed, produced and used. In line with Arkrich et al. (2002) Håkansson (1987: 3) describe innovation as: “*An innovation should not be seen as the product of only one actor but as the result of interplay between two or more actors; in other words a product of a ‘network’ of actors*”. Through relationships *actors* (individuals, companies, or units of an organization or company etc.) can combine *resources* (knowledge, products, facilities, equipment, relationships, routines etc.) and link *activities* (production, R&D, logistics etc.) in order to achieve innovation. By adapting resources and activities actors become interdependent over time, which has consequences for innovations. Any innovation gives rise to changes in the network as innovation requires reshuffling of the activated resources and activities among actors in the network in order to be embedded into use (Håkansson & Waluszewski 2007). Due to the interdependent network innovations can create both direct and indirect effects, for instance a new innovation may cause direct effects on a relationship between a customer and a supplier but may also cause indirect effects to other relationships related to the two actors, such as relationships to sub-suppliers or the customers’ customer. These effects not only stretch organizational boundaries and temporary project networks but also stretch permanent networks (Dubois & Gadde 2002). In gaining understanding of how an innovation as BIM is used along what effects the innovation imposes the paper apply an industrial network approach. More specifically the ARA-model (Håkansson 1987) is applied as a suitable tool to actually capture how BIM as an innovation have been adopted among construction actors as well as what effects the innovation creates on actors, resources and activities within the Swedish construction sector.

## **Method and data collection**

In being able to answer the research questions the research project is based on a qualitative approach. Such an approach has been suggested as a suitable method when capturing interactions among actors and their perceptions of a phenomenon (Yin 2003; Visconti 2009). The data has mainly been collected through interviews with informants representing Swedish construction actors. More specifically, the study is an in-depth interview study with informants representing various actors in the construction sector; construction companies/contractors, architects, technical engineering companies, clients/project owners, suppliers, other organizations such as NGOs and lobby organizations. Earlier research

(Bygballe & Ingemansson 2011) indicates that main innovation activities in the construction sector are performed by large organizations; hence the investigation focuses on the largest companies or organization of each actor group. In total 23 interviews have been performed with informants representing all actor groups, however the empirical data for the paper mainly focuses on four actor groups; construction companies/contractors, architects, technical engineering companies, clients/project owners. Through the data collection an overview of the Swedish construction sector can be captured, i.e. its main actors and their view on how BIM is used and what changes BIM evokes.

## **Empirical description**

The following empirical description will illustrate how four different actor groups (technical engineering companies, contractors, architect firms and project owners/client organizations) use BIM in various ways. I will present each actor group separately and illustrate how the specific actor group work with BIM and what changes BIM have evoked. The intention of the empirical description is to provide an overview of the empirical material covering a variety of actors groups, including both similarities and differences within each actor group.

### ***The use of BIM among technical engineering companies***

In general the actor group has employed more BIM specialists during the last 5 years, and several of the companies have established specialized BIM units along with BIM policies. Moreover the companies also offer BIM training among the employees as a way to spread the basic BIM knowledge within the organizations. One of the studied companies have however not yet an internal policy in relation to BIM and the firm only have one BIM specialist employed in the whole organization. Instead the company emphasizes the need for individuals to participate in large 'live' BIM-heavy construction projects. The company hence employs 'learning by doing' as the way to enhance BIM expertise and knowledge within the organization.

Early on the technical engineering companies realized the benefits of adopting and using BIM as a way to develop new services to customers. As these companies work as consultant the companies first used BIM with an external focus, i.e. focus on the customers. Hence the technical engineering companies have been concerned with determining how BIM could be 'package' to be sold to clients. Thereafter the companies have been focusing to establish its internal BIM competence through specific policies, units, training mentioned above.

When the companies started to adopt BIM the companies focused at construction companies and contractors as main clients. As these companies have developed and adopted BIM and established BIM competence the consultants are now focusing on providing BIM services to developers and project owners as main clients. This change is reflected by a BIM manager at an engineering company when saying: "*Today my client is the developer not the entrepreneur [construction company]*" (BIM manager, Engineering consultant A). The engineering

consultants are mainly employed as BIM coordinators by project owners and developers but also as consultants for providing BIM expertise for establishing specialized BIM units or defining BIM policies within client organizations.

The engineering companies especially highlight the ‘extreme’ projects as driving the adoption and use of BIM in Sweden. These projects are recognized as forcing the industry and its actors to develop and step forward in relation to BIM. A reason for extreme projects driving the development of BIM is both due to the complexity of the projects and that these projects have huge budgets which create ‘room’ for development and innovation. New Karolinska Hospital (NKS) is mentioned as ‘the BIM project’ and it is recognized that several solutions and work processes developed in NKS have been spread to other projects and organizations. For instance EES in Lund uses the component database developed in NKS and it has also been diffused to the real estate developer Locum.

### ***The use of BIM among contractors/construction companies***

The small house manufacturing firms was first to adopt and see the benefits to use BIM to optimize its processes among the Swedish contractors. A few year later (late 2000s) the large Swedish construction companies also realized the benefits of BIM, especially how BIM could be used to its internal projects and projects with design & built contracts. In being able to make use of BIM the contractors have adopted BIM policies during the last years. As a consequence the companies invested in developing specialized BIM units, employing new personnel with BIM competence and providing BIM training to a larger extent. Through this increased internal BIM competence the contractors hoped for diffusing BIM knowledge throughout the companies, not only to individual projects. There are however some companies focusing less on employing and developing employees into BIM experts and instead try to integrate BIM competence in existing roles through training.

Contractors perceive themselves as well as the technical engineering companies as main drivers of BIM in Sweden. All companies however recognize that BIM requires more time and effort in relation to design and planning activities. Also when implementing BIM in early phases construction companies need to provide new information when providing bids, for instance companies need to describe how the company will use existent building information in the production stage.

Two large Swedish contractors decided to adopt the Virtual Design and Construction (VDC) - concept developed by Center for Integrated Facility Engineering (CIFIE) at Stanford University. VDC refers to a whole methodology in relation to managing building information throughout a buildings life cycle. In implementing VDC the companies attended BIM training at Stanford and have now more than 30 Virtual Design and Construction (VDC)- licenced specialists in each company. Cifie also have paid visits to the companies in Sweden to define how the companies could use BIM more systematically throughout the organizations. Implementing the VDC-methodology have changed how the construction actors interact especially in the design and planning phase. During specific planning and design meetings, so

called Integrated Concurrent Engineering (ICE)- meetings all construction actors are present. The meetings rely on direct interaction among a variety of actors, and it is estimated that 90-95% of the work will be performed during the meetings. Through direct feed-back at the meeting efficiency and communication among the actors is enhanced. Technical engineering companies and architect firms especially emphasize good experience from ICE-meetings and VDC-methodology.

### ***The use of BIM among architect firms***

During the last years (2-3 years) architect firms have realized the need for establishing BIM competence within the organizations. The majority of the firms (3 out of 4) have BIM policies and have appointed dedicated teams to provide BIM training or specialized BIM units with the aim to better spread basic BIM knowledge within the organization. More architect firms are now employing model managers and building engineers. However there is a lack of finding suitable and experienced employees with both technical skills and experience from project- and process work. As a consequence there are only few individuals within each firm that possess high BIM competence.

There is a general consensus among the architect firms that architects have been slow at adopting new technology and BIM in particular. The reason why architect firms lag behind in adopting BIM may be due to the architect profession where creativity have been rewarded, while technology is seen as instrumental and ‘hindering’ creativity. Thus BIM for architects is mainly a tool for visualization, not a tool for storing information about a particular building. This view is reflected by a BIM-manager as he says: *“Architects are architects and do not care about information delivered to operations management”* hence *“the information flow is not what the architects are ‘burning’ for”* (BIM-manager, Architect C). Another BIM-manager illustrates this by the response which he got from one architect when he was introduced at the new firm: *“I use this to design [pointing at the pencil], I do not use that [pointing at the computer]”* (BIM-manager, Architect B).

The change toward BIM policies and increased BIM competence among architect has not been easy and all firms have experienced reluctance within their organizations towards adopting BIM. BIM managers at architects firms find it difficult to internally explain what BIM is and what benefits it may bring to the organization. In relation to the lack of insight in BIM and its benefits one BIM manger says: *“I needed to implement our role [a BIM unit] within the organization and I have spent a lot of time convincing my boss that we are not IT”* (BIM-manager, Architect A).

The increased use of BIM at architects firms have not only resulted in BIM units, BIM training and new employees but also in increased investments in BIM-related software. Some architects also mention that they experience a ‘lock in’ due to a particular software tool. As a consequence several of the architectural firms complained about how directed their work have been in relation to the software itself along with the software suppliers.

The architect firms also mentions the importance of BIM skilled client organizations (developers/project owners) in establishing a good BIM base in the Swedish construction sector. The main parts of client organizations are however not able to make detailed and relevant BIM requirements and both architect firms and technical engineers play important roles in ‘educating and training’ clients. In line with the technical engineering companies the architect firms also emphasize the importance of ‘good examples’ such as specific BIM heavy projects or specific solutions that are BIM related. For instance Veidekkes new product Veidekke Max along with the VCD-methodology and ICE-meetings are viewed as inspiring in relation to BIM. Also NKS and the joint collaboration between several architects in the White Tengbom Team (WTT) is mentioned as a good example. All large architect firms in Sweden have been involved in WTT and NKS one way or the other. Moreover the EES-project in Lund and the Skandion Clinic in Uppsala is also mentioned as inspiring examples in using BIM. One BIM-manager however mention the difficulties of transferring knowledge and experience from extreme projects to normal-sized projects as: *“The focus is on large high-end projects but no one cares about average projects, how can we implement experiences from extreme projects to average projects? This is a main issue that few are interested in”* (BIM-manger, Architect D).

### ***The use of BIM among developers and project owners***

According to several construction actors client organizations, such as developers and project owners, have been slow in adopting BIM. In general it seems like the clients had difficulties in understanding the benefits of BIM in maintenance and operations. However it seems as the public developers and project owners plays an important role in relation to adoption of BIM among client organizations in Sweden.

For instance the Swedish Transportation Administration (TRV) has been appointed by the government to lead the implementation and BIM among public project owners. In late 2013 the company stated that all projects should use basic level BIM until June 2015. Another public project owner initiative is the public initiatives among 5 public clients referred to as ‘BIM among public owners’. The public developers; Akademiska Hus, Fortifikationsverket, Statens Fastighetsverk, Riksdagsförvaltningen and Specialfastigheter, have jointly developed a BIM handbook, a manual with the aim to standardize BIM in the public sector. As the manual not yet have been used for any live projects is described as: ...”[BIM among public owners] *is a paper tiger as it is now but a very good paper tiger but practical examples are necessary in order to achieve something [concrete]*” (BIM-manager, Architect A).

Due to the increased focus on BIM among large project owners BIM specialists and BIM training have been more common among client organizations. In developing BIM client organizations are benchmarking against public client initiatives in Norway, Finland and the UK. There seems to be a variety of how the client organizations perceive and implement BIM, and the public clients are more inclined than other client organizations to implement and adopt BIM. For instance one the largest private real estate company in Sweden has just started to work with BIM without appointing BIM specialists and establishing BIM units. Instead the

company is focusing on including BIM work within the existing IT unit. So far the company has just had one pilot project in which BIM has been prioritized, a project to large extent driven by the contractor along with an appointed engineering consultant. Thus it is evident that client organizations not only employ people with BIM competence but also rely on assistance from both contractors and technical engineering companies to define and establish its internal BIM competences along with BIM in particular projects.

According to several construction actors one public developer is identified as leading adoption and use of BIM in Sweden; Locum. The company is the real estate company is owned by Stockholm County council and manages all public healthcare buildings within the Stockholm area. The organization has implemented several solutions from the NKS-project in its organization. It is however not surprising that a real estate developer within healthcare is taking the lead in developing BIM as healthcare facilities are described as impossible to construct without using BIM due to its complexity.

As client organizations rather recently started to work with BIM, the focus has mainly been identifying and determining what information is necessary for future maintenance and operations. At the moment BIM is not used for maintenance as the existing information systems cannot handle BIM information. As a consequence client organizations are working with software supplier and IT companies to develop suitable systems for operation and maintenance management. Thus the clients are mainly involved in defining the basic requirements on basic information for future use of BIM in operation and facility management.

### ***Concluding discussion***

The empirical description illustrates that all investigated actor groups have established BIM policies, BIM units, BIM training and BIM methodology in various ways. Technical engineering companies and contractors have however been early adopters when using and adopting BIM in Sweden, whereas architects and project owners have been latecomers in using BIM. In general the use of BIM has required the (re-)allocation of large financial resources in establishing BIM competence and knowledge base along with large investments in new software solutions.

Architect firms and client organizations have experienced problems to internally establish and develop its BIM competences due to the difficulty among the organizations to see the benefits of BIM. On the other hand it seems like several individual projects involving all actor groups have used and adopted a high level of BIM. Still these 'extreme' projects are limited in number and thus few projects use BIM with the intention to use it throughout the whole construction process. In these 'extreme' projects construction actors interact intensively and some experiences and solutions have spread to other 'extreme' projects. However it seems difficult to transfer solutions and experiences to more average or 'normal' projects. Thus this indicates that the use of BIM in Sweden has just begun, only few projects is directed by the view on BIM as a management tool stretching the whole life cycle of the building object.

Instead BIM is mainly used as a tool for visualizations and coordination in design and planning. As a consequence BIM have mainly affected design and planning activities, while production activities are increasingly steered by BIM, for instance in coordinating logistics and procurement activities. Effects on design and planning activities have been the need for allocating more resources to coordinate these activities because BIM requires increased interaction among construction actors which is time-consuming. VDC methodology for instance result in changing work processes from more individual work processes at isolated offices to jointly work processes at meetings at the construction firm or the production site.

The maintenance activities have not yet been affected to a large extent due to immature client organizations along with lack of resources in developing sufficient information systems for handling BIM-information for maintenance and operations. However the empirical illustration shows that client organizations play an important actor role in demanding BIM when initiating new projects. Public project owners have just started to identify and determine specific BIM requirement and it is evident that the client organizations are dependent on interaction with contractors and technical consultant to develop its BIM competence and BIM requirements.

As the various construction actors have invested resources to establish and develop BIM competence new actor roles have been established such as model managers, BIM-coordinators and BIM-managers. These actor roles include responsibility in handling the models and modeling itself along with coordinating several BIM models stretching several organizations and projects. Although all construction actors have recognized BIM as important it is evident that the actors tend to mainly focus on the benefits of its own organization, i.e. to optimize its own work in each specific project. Thus there is a tendency among construction actors to only see BIM from one actor perspective, which in itself is a problem as BIM is described as a: “*Collaborate way of working*” and you...”*Need to understand that we work together ...and all actors need to take a joint responsibility for the process and for cooperation*” while “*almost no one work keep track on the bigger picture [stretching various phases, actors and activities]*” (BIM-manger, Architect A). This indicates that actors tend to see BIM from a joint perspective which can hinder the adoption and use of BIM in the Swedish construction sector.

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