The impact of BIM on risk management as an argument for its implementation in a construction company

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Abstract

This paper examines the impact of the Building Information Modeling (BIM) implementation on the construction market, where BIM is not common yet. As long as the client does not require using BIM, construction companies often struggle when trying to find arguments for BIM implementation, which would outweigh all obstacles encountered during the way. Several BIM benefits can be identified of which one of the most important is the BIM impact on risk management. The objective of this paper is to investigate the importance of risk management and BIM relations as an argument for implementation of BIM in a construction company. It focuses on the risks related to BIM implementation processes, i.e. processes related to implementing new systems in a construction company, and risks related to BIM application processes, i.e. processes related to actual BIM use in a construction company. Although there are serious threats involved in the first group, there are many opportunities emerging from the second one. Risk (threats and opportunities) identification in both of these groups and finding their correlation can then be used as a supporting argument for BIM implementation. The research methods are based on conducted surveys and literature research. These sources were analyzed and used for the case of explanation and for the identification of key risk and BIM related issues. The research reveals whether the topic of BIM related risks is mostly treated only on a common level and whether BIM regarding risk awareness of those who have not been using BIM is sufficient enough to evaluate all advantages and disadvantages of BIM implementation. In the end, the paper suggests a possible method to describe BIM related risks. The understanding of these risks and their connections allows construction companies to build arguments better when considering BIM implementation into their practice.

Keywords: BIM, BIM Related Risk Awareness, Building Information Modeling, Implementation, Risk Management.

1. Introduction

The Building Information Modeling (BIM) is a highly discussed topic nowadays. In some parts of the world, BIM has become common, usually by the means of some degree of standardization and government support. For example, such is the case of Finland (buildingSMART Finland, 2012), the United States (National Institute of Building Sciences, 2007) or Singapore (Building and Construction Authority, 2013). There are other countries, like the United Kingdom, where there is a big BIM boom. In case of the UK, it means there is huge government support, aiming to use a certain level of BIM in all centrally procured projects by 2016 (UK Cabinet Office, 2011). Then there are countries, especially in the southern and eastern Europe, which are starting to develop their interest in BIM. The usual propagators of this new technology are big construction companies (whose parent companies are already BIM ready or at least included BIM in their longer-term targets) and smaller young enthusiastic companies (because they are more flexible and more interested). Another very important part is played by government (Eastman, et al., 2011), which create an environment for BIM implementation (especially in the form of standardization and public contracts). They all need to ask these easy but very specific questions, which are not easy to answer: What are the benefits of BIM? What are the drawbacks of BIM? What will BIM cost me?

This paper targets issues connected with BIM implementation in construction companies on the market, where BIM is not common yet. It tries to provide a rough explanation of how the aforementioned questions can be partly answered by looking at risks during the BIM implementation process and actual BIM use.

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1.1. **BIM overview**

BIM is a modern construction management process, which allows users to create object-based multidimensional parametric models as a tool for construction projects management during their whole life cycle. For this purpose, various tools and methods are being used. There are also procedural adjustments, aimed especially for collaboration, revisions and efficiency. Therefore there are the two main groups, which define the role of BIM in a project - tools and methodology (Race, 2012). Tools are not only software tools, although these are the most important. Heavy machinery, fabrication machines, computers, tablets, geodetic tools, visualization tools, GPS or microchips and RFID technology are also part of the tools group. Methodology group is much more complicated, since it defines how tools will interact, how they may be used by people and how people interact with each other. This second group defines the success of BIM implementation in a construction company nowadays.

The concept of BIM is not new. An object-based parametric modeling has already been used in different sectors, for example in chemistry, mechanical engineering or electronics (Eastman, et al., 2011). It just took a little bit longer until these technologies found their way to construction industry, mainly because construction projects are unique, very complex and long-running. They also demand a very high amount of resources. Because of this nature of construction projects, the whole process of BIM adoption is not simple. BIM is a hot topic nowadays, spreading around the whole world, promising better, more efficient and higher quality construction projects with a positive impact in reducing whole life-cycle costs. BIM on the national markets differs a great deal and is based on a country’s technological level and degree of government support.

BIM can be used during the whole project’s life cycle. From programming, design phase, construction phase and operating phase, ending with demolition or renovation. During this cycle, BIM can be used in many different fields. These include a long list of different areas. This list includes current conditions modeling, budgeting and quantity takeoff, time planning, programming, and site analysis. Other areas that can use BIM are project review, certification and standardization, project design, engineer analyses, sheets and documentation creation, 3D coordination and planning, and site design. And lastly could include operational planning, digital fabrication, planning and management, as-built modeling, construction analyses, facility management, maintenance and reconstruction plans, space management, and crisis management. In each of these fields, there is a risk involved and this risk has to be managed.

1.2. **Risk Management overview**

According to ISO 31000:2009, a risk is the “effect of uncertainty on objectives” (Anon., 2009, p. 11). Every part of project life cycle is subject to risks (Tichý & Erben, 2006), which have to be treated adequately to stay in control of the project and to achieve its goals in an optimal way. Risk management is a set of activities, aimed to analyze (identify, assess), evaluate, treat and monitor risks.

Risks are defined by their defining events and levels (likelihoods and consequences). It is possible to look at the risk as a two-dimensional quantity. The first dimension is its likelihood, which means it is the probability that event will occur. The second dimension is its consequences, which means the severity of risk (event) impact in case risk scenario happens. The severity may be described numerically or verbally on the appropriate scale. The combination of risk likelihood and consequence results in the creation of risk level. The risk matrix is when levels of all identified risks are plotted into a diagram, where two dimensions mentioned are the two diagram axis. Other important terms regarding risk management are the risk owner, risk source and the risk recipient. The risk owner is a system entity, which has authority and is responsible for managing risk (ISO 31000, 2009). The risk source refers to a system entity, which is a possible cause of the risk (event). It means when the risk source is removed from the system, the risk scenario cannot happen in the system, which also means it cannot be managed. The risk recipient is the entity of the system which will suffer the consequences of the risk in case the risk scenario is realized. There may be one or more (or none) risk owners, risk sources and risk recipients, related to one risk. It is advised that relationships between risk owner, sources and recipients are clearly identified. The risk recipient may or may not be the risk owner. Risks may also be characterized by their context, which may be external or internal (ISO 31000, 2009). External context describes relationships between an organization and the environment, while internal context describes relationships inside an organization.

1.2.1. **Threats and opportunities**

In common language, risk is usually referred to as something negative. In the risk science, the risk is neutral in its nature and it is subjective. When an event happens, it may be understood as positive or negative, based on the risk owner and risk recipient perspectives. A benefit for one, may bring harm to another. This dimension is
called *polarity*. Therefore there are positive and negative understandings of events and risk, which are called *chances* and *hazards* (for events) and *opportunities* and *threats* (for risks). In practice, these terms are often used interchangeably, for example a hazard is often used as a reference to an event (Edwards, 1995). When risk happens, it may bring *benefit*, or it may cause *harm* or both. The ability to see risks not only as threats, but also as opportunities, is very important.

1.2.2. Risk correlation

Every risk may be objectively characterized by its likelihood, subjectively by its consequences. But there are other risk attributes, which can be identified. These attributes are usually linked with risk events and risk sources. Based upon these attributes, it is possible to classify risks and to identify their common characteristics. Sometimes, attributes are connected. This connection may be mathematically described as a correlation, usually represented by specifically designed coefficient or function. The most common coefficient is the Pearson coefficient, which is defined on the interval from -1 for anti-correlation to 1 for full linear correlation, while 0 means no linear correlation at all. In case of more complicated correlation, non-linear functions need to be used (Dietrich, 1991). When there is proportionality in correlation between two risks, it’s called positive risk correlation (one risk have positive impact on another risk and vice versa), analogically when there is inverse proportionality, it’s called negative risk correlation (one risk has negative impact on another risk and vice versa). Sometimes, risk correlation may be one-sided, which means the relationship is only valid from one risk to another. The correlation may also be the combination of all cases mentioned above.

1.3. Risks in BIM

The topic of risks is very important in BIM. There are some major threats when BIM is being implemented in a construction company as there would be any time when innovation is involved. When BIM is being used, there are big impacts on standard risks levels, but there are also new threats and opportunities emerging. Since the topic of risks is very subjective and is often an objects of private know-how, there are not many sources, which would address BIM risks in detail.

In various BIM oriented publications, the risk is usually mentioned. These mentioned risks are usually referred to as the risks, which are influenced by the BIM use or its implementation, or the risks inherent in BIM as their risk source. Eastman in his preface of the *BIM Handbook* writes, that the “BIM creates significant opportunity” (Eastman, et al., 2011, p. xi). In this book, the risk is usually referred to in a positive way such as risk reduction or opportunities. It is said that BIM may “reduce the financial risk” (Eastman, et al., 2011, p. 151), “reduce schedule-related risks” and “decrease the risk for errors and omissions” (Eastman, et al., 2011, p. 247). The fact that BIM increases risks is considered a misconception (Deutsch, 2011). There are also tools specifically designed to minimize risks (Epstein, 2012, p. 80).

Based on the stakeholder role in the project, various BIM related risks may be addressed. During the design phase, there are opportunities involved (Eastman, et al., 2011, p. 197). Also there are some concerns about the risk increase for designers (Teicholz, 2013), especially in the field of deliverable definitions, ownerships and liabilities. The opportunities in automation (Eastman, et al., 2011, pp. 214, 295) are also mentioned, especially in fabrication (Eastman, et al., 2011, p. 333). For the contractor, BIM can reduce the risk over time (Eastman, et al., 2011, p. 302) and “a detailed building model is a risk-mitigation tool” (Eastman, et al., 2011, p. 276). For subcontractors, the risks “associated with parts not fitting correctly when installed” (Eastman, et al., 2011, p. 322) are reduced. According to Eastman, BIM also “reduces risks for client” (Eastman, et al., 2011, p. 268). Which Teicholz reaffirms in his *BIM for Facility Managers* (Teicholz, 2013). It is understandable, because of the costs during project operating phase and because owners are usually at the end of a normal cycle, where most of the BIM benefits are realized. Regardless of the stakeholder role, BIM brings opportunities in an increased level of communication (Deutsch, 2011). BIM is also said to have positive impact on the environmental risks (Krygiel & Nies, 2008). BIM can be “effectively utilized by parties to assume more risk while reducing contingencies” (Reddy, 2012, p. 43). The whole concept of Integrated Project delivery (IPD) is also considered as having positive impact on risk reduction and BIM may be considered to bring appropriate tools and processes according to IPD philosophy. There are also concerns about legal and financial risks (ownership, liabilities, insurance etc.), which, on the other hand, can easily be managed by proper communication and contracting.

In various case studies, the specific risks are sporadically mentioned, as they are a part of the construction process. Such case studies are easily found in the Eastman’s *BIM Handbook* (Eastman, et al., 2011), Epstein’s *Implementing Successful BIM* (Epstein, 2012) and Jernigan’s *BIG BIM little bim* (Jernigan, 2008). Case studies aimed at BIM implementation in facility management can be found in Teicholz’s *BIM for Facility Managers* (Teicholz, 2013), but these case studies rarely deal with the risk management.
In scientific papers, any BIM related risks are often mentioned while specific BIM tools are described. For example, these are clash-detection tools (HyounSeok, HyeonSeoung, ChangHak & LeenSeok, 2014) or safety planning (Sulkankivi, Makela & Kiiviniemi, 2009), (Chan-Sik, Hyeon-Jin, 2013). Other papers examine BIM as a risk source, for example risks connected with legal issues (Su-Ling, 2014), (Arensman & Ozbek, 2012) or investment risks during BIM implementation (Tsai, Kang & Hsieh, 2014). In a very interesting paper called Building Information Modeling (BIM) for existing buildings — Literature review and future needs, describes the possible use of BIM for existing buildings. Various benefits of BIM for risk management are mentioned, but it is also mentioned that the sources for risk scenario planning are rare in literature today (Volk, Stengel & Schultmann, 2014). The project benefits of Building Information Modelling (BIM) defines various benefits of BIM for project management based on 35 case studies. One of these benefits is risk management (Bryde, Broquetas & Volm, 2013). The impact of BIM on risk management is described only briefly and there are no correlations identified.

Based on interviews (Matějka, et al., 2012) and literature research, public knowledge about BIM related risks in the Czech Republic, which is a country where BIM is not being used yet, is not high. People often see the innovation risks as threats and they fail to see the opportunities of innovation. There are the two main reasons. The first reason is there is not enough clear information about BIM benefits, and the fact that they are not influenced by marketing materials of tool providers. The second reason emerges from construction industry itself, because it is hard to generalize BIM implementation harms end benefits as they are subject to specific project, company and market conditions.

2. BIM implementation

With new technologies, new issues arise. One of these issues deals with the topic of BIM implementation into a construction company. It is not just about switching between the tools used, it’s more about adopting new work processes. Technology and quality of BIM tools were an issue ten years ago. Today, it is about successful and efficient BIM implementation into common use, which means especially a successful use of BIM by the personal on the project and at the project team level. When standardization occurs, the current practice shows, it does achieve a level of collaboration (Epstein, 2012). The question of implementation today is “How should we do that?” instead of “Is it possible?”

The whole BIM implementation process can be divided into the two main categories. The first category is the implementation phase. The second category is the post-implementation phase. These two phases are connected and may overlap. They also form a cycle, meaning after a post-implementation phase, there may be more implementation processes. Also, information gathered during previous implementation and following post-implementation phase may be used as a guidance for a different company or project. During its post-implementation phase, BIM may be utilized to obtain various benefits during the whole project’s life cycle. These benefits are hard to categorize, because they may overlap and are often connected (Eastman, et al., 2011; Kymmel, 2008; Epstein, 2012). They are generally: lower cost of construction project during its whole project life cycle, higher quality of the construction project, more efficient design, construction and operating phases. This leading to faster construction phase, better safety during the whole project life cycle, lower waste production, better ways to manage risk, fewer errors, and higher productivity.

There are also factors, which may end up as failure during BIM utilization, if not properly managed. Some examples of the most important factors are: proper communication during project (especially during the design phase) and proper collaboration during project (not only in a company, but collaboration with other stakeholders is important too; also covers the topic of responsibility). This can lead to project continuity in the terms of its different phases (for example when construction phase is finished and operating phase starts (Teicholz, 2013)), dealing with the continuity and the long-term character of construction projects, readiness of legislative and legal environment, standardization and methodology (to understand each other), readiness of contractual environment (i.e. what is deliverable?), capital expenditure (not only acquisition costs, but qualification and innovation too), software and technological support. The best way to deal with these factors is firstly to adopt BIM and then implement it (Deutsch, 2011). It usually takes one or two projects to test newly implemented BIM processes (Epstein, 2012) and it usually takes around three years to anticipate results of BIM implementation process (Race, 2012), remember that it has been shown when using BIM, projects “save 5-12%” (Jernigan, 2008). Any time a firm implements any new process, which applies to BIM implementation too, quality control and risk management are often considered as the two most important guidelines for every firm owner and manager (Epstein, 2012) to consider.
3. BIM in risk management

BIM has impact on both the external and the internal risks in a construction company. These risks can also be divided into the implementation and post-implementation phase, as has already been explained in this article. It also differs based on the degree of implementation on the examined market. When in a market, where BIM is already being widely used, it is more about maintaining competitive advantage, managing opportunities and not staying behind. In the market where BIM is not common yet, the innovation risks which need to be managed are much larger, concerning both threats and opportunities. Successful innovation risk management is crucial (Smith & Tardif, 2009). It is important to build a business case for the use of BIM and there are many ways to do that, since there are new opportunities, which come with the BIM use (Race, 2012).

When BIM is used, it should have positive impact on risk management, i.e. it mitigates threats and raises opportunities. When BIM is being implemented, there are many risks involved during this process, of which the majority are threats. It is usual that every innovation carries risks, but “the risk of implementing BIM technology is far lower than implementing CAD” (Smith & Tardif, 2009, p. 33). It is advised to take a proactive approach to manage risks and to share these risks (Jernigan, 2008).

3.1.1. BIM related risks relations

As stated before, the BIM implementation phase is usually connected with many threats. These threats can cause harm to the risk recipients. This harm can be expressed as costs, and also their treatment. Implementation phase usually does not carry any opportunities for a construction company. Post-implementation phase is connected with both threats and opportunities. The situation is similar to the implementation phase. However, using BIM carries many opportunities, which may result in various benefits (i.e. competitive advantage, threats mitigation, lower costs etc.) When considering the BIM implementation, there are two rules of thumb, which have to be met. The first is that total costs of the implementation, together with their consequences, should be lower than total benefits, together with their consequences (on the examined time period). The second rule is, that costs during the implementation should be bearable on the operating level. One problem is calculating future costs and benefits and putting them together. This creates a big factor of uncertainty, which has to be dealt with. This uncertainty may be easier to manage, if proper relations between involved risks during implementation and post-implementation phases are properly identified and mathematically described so they can be used as correlations. Such information could then have two major uses. The first use is for the risk management. The second use is for decision-making during the BIM implementation process. Explained relations can not only help to understand risks involved, but they also help to identify crucial factors of BIM implementation to optimize the whole process. The key risk attributes, with some relation to other risk attributes are: likelihoods (probabilities), consequences, related events, polarity, risk owners, risk sources and risk recipients. Described principle can be easily used in every implementation process, but when implementing BIM, it is especially important. This is because of the very high BIM influence on risks, insufficient information about BIM and how it affect risks, unclear BIM-related risks relations, nature of construction projects and big differences between BIM implementation and post-implementation phases.

4. Conclusion

The presented paper examined and explained the topic of risks during BIM implementation process. It focused on the market where BIM is not common yet and it proposed that it is possible to analyze the BIM implementation process with regard to BIM-related risks and their relations between implementation and post-implementation phases. The identification of BIM-related risks correlations can then be used to not only to bring more efficiency to BIM implementation process, but also to better understand BIM threats and opportunities during both implementation and post-implementation phases. As the literature review shows, risks are often considered as an area which is heavy influenced by the BIM implementation. The impact of BIM on risk management processes can also be considered as the main advantage of the BIM. Unfortunately, the correlations mentioned are not clear and vary based on the project differences. Therefore further case-study oriented research is needed to describe proper risk correlations model. Such models could then be used to support BIM implementation process and to better utilize risk-related advantages of BIM in construction projects.

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