The Fifth Dimension of BIM – Implementation Survey

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Abstract. In today's digital age, the rate of process automation is increasing. Building Information Modelling (BIM) is being used for this purpose. BIM is a smart, model-based process that provides construction professionals with an overview and tools for more efficient planning, designing of building solutions, facility management of buildings and infrastructure. Cost management represents a very important part of BIM technology. 5D-cost model in Building Information Modelling is used for budget monitoring and cost analysis. 5D-cost model allows to directly extract individual quantities and then assign unit costs to them. 5D-cost model increases level of safety and reduces or makes use of cost at all stages of the construction project more efficient. The paper discusses the issue of the fifth dimension of BIM. The main objective of survey was to create overview of 5D (BIM) implementation in selected countries and to bring comparison within this topic. Based on a thorough analysis of the sources, the overview and comparison was carried out. The main conclusion of the research suggested that the selected countries have a different degree of 5D BIM implementation.

1. Introduction
Building Information Modelling presents a tool which brings positive influence on digital ability enhancing. In context of civil engineering industry, BIM means a process of feeding assets through well-structured digital information. Availability of digital information for all participants is a priority [1] as it contains space information, material characteristics and allows different participants to exchange and update information. In the past, BIM was used mainly as a visualization and organization tool, from the domain of AEC (architecture, engineering and construction) and industry entities. Today the purpose of BIM usage has changed and it is used as a process of improving performance during the whole life-cycle of buildings [2].

BIM model is more than a 3D model. BIM represents common data environment. The common data environment can be divided in graphical and non-graphical information. 7 established dimensions exist according to BIM principles, which are:
- 3D – geometry,
- 4D – time,
- 5D – costs,
- 6D – sustainability,
- 7D – facility management [3].

3D shows graphic data. It is the most known dimension, because it is related to the “visible” part of a BIM model [3].
4D BIM is four-dimensional modelling of information about buildings and it is used for all actions related to construction site planning. It is possible to visualize and control action process throughout the whole lifetime of the project. Contractors and producers can optimize their activities, all deliveries, stocking etc.[3].

5D is used for budget monitoring and cost analysis. Creating the building budget is one of the most important parts of the project life-cycle. Main task is to exactly specify the cost of building work, including profit. It is difficult to specify the costs and profit amount in the building budget from the point of documents quality, but it depends also on the calculation method. It is possible to extract amounts from 5D directly and immediately with high level of accuracy [4]. By assigning single costs to amounts, accurate and reliable costs analysis can automatically be acquired. If the total costs do not reflect client’s requirements, it can lead to inefficient change in management in real time [3]. An integrated solution for providing the information inputs and data streams to BIM is needed for the efficient functioning of 5D modelling [5].

6D BIM dimension is used for reviewing energetic efficiency during the project and operating stage. Efficient data collecting allows better understanding the building’s performance and defining strategy focused on optimization of building’s energy consumption [3].

7D dimension is used for collecting relevant information about building’s operation and maintenance state and devices during their lifetime. 7D is mainly a data model, intended for administration and maintenance of buildings [3].

In 2014, Guideline 2014/24/EU was released. It states , that BIM is a non-discriminatory medium for competition and transparency support in public contracts. Despite the fact that BIM is not mentioned in the guideline, there is uncountable number of references which prove BIM to be a tool that helps in achieving goals, for example the fact that basic data pattern is IFC [6].

BIM is an electronic communication medium, thus it is a tool that allows user to require complex information about building contract in ready-defined structured form. Based on these facts, BIM offers higher level of transparency, control, evaluation and sharing of data [6–7].

2. Methodology

2.1. Problem explanation
BIM technology is one of the most progressive tools for integrated design and sustainability in AEC. In spite of being known for a long time, the term BIM has not been yet used in all parts of the world. Usage rate of BIM is probably relatively different. Perception of BIM technology and possibility of its use is also different. It is interesting to follow the views on BIM in the context of the cost of the construction project. BIM is not just a designing tool. However, all countries do not speak of a comprehensive solution. In particular, the cost management area (or also the fifth dimension of BIM) is correctly and clearly perceived in all countries. Cost estimate and cost management are often carried out in other software environments. Understanding the complexity of BIM is therefore a very sensitive topic. For better use and understanding of BIM in the construction industry, it is necessary to know current state of implementation and use of this technology. Based on the degree of BIM implementation in individual countries, different perception of the BIM technology benefits can be perceived. It is therefore necessary to think of and explore this area as well.

2.2. Research areas and objectives
Based on the definition of the problem explanation, the main desirable areas of survey in this field have been identified. These areas of research were based on the need to know the current state in the following areas:
- Perception of benefits after implementation of BIM in 5D context,
- Software tools and applications that allow cost estimate and cost management in BIM,
- 5D (BIM) implementation in selected countries.
The research is based on analyzing of already carried out research focused on the BIM state of implementation in cost estimating of the building production in selected countries. Based on this, the main objective of the research was set which is to create an overview of 5D (BIM) implementation in selected countries and bring comparison in this field. In order to achieve this main research objective, it was necessary to meet the partial objectives in the areas. Partial objectives were set as follows:

- Specify the 5D BIM model of benefits and barriers,
- Bring overview of software applications in the 5D context,
- Bring overview and comparison of current state of BIM 5D implementation in selected countries of the world.

2.3. Research processing

Achieving the objectives of the research was prevented by a number of research tasks that needed to be accomplished. Firstly, a number of studies and existing surveys about this topic and problem were studied. The surveys identified were analyzed in detail. The information obtained and the results were sorted according to the selected regions and countries. This information was mainly based on survey findings based on the basics of the report and final overview. Research has brought theoretical analysis of 5D dimension, has mentioned its benefits, has offered an overview of the software application allowing 5D model creation and brings an insight into actual state of BIM implementation in the cost estimating and cost management process.

3. 5D cost estimate

Construction activity is characterized by high amount of input information, which is important to be taken into account during the whole construction process. BIM allows brief and effective working with information. Informative or virtual model is filled with information from the beginning. This is a basic presumption for its future usage in each phase of the project. BIM has many dimensions, which extend and supply geometric representation of objects in 3D environment. One of them is the fifth dimension of the building information model, worldwide known as 5D BIM, formed by finances. As a tool, BIM helps 5D to follow exact need for resources in each phase of a life-cycle and allows better planning of financial aspects of the project, thus finances are under constant control. 5D does not include only calculation and cost estimate. Overall 5D model is dependent on processing quality of its parts. It is based on 3D parametrical model, from which it is possible to create and export a bill of quantities. This bill of quantities includes all projected elements, constructions and objects [8].

3.1. Benefits and barriers of 5D BIM

There are several studies dealing with benefits and barriers of 5D BIM. Some studies focus on 5D BIM implementation, while others focus more on practical use of a 5D model [9].

Lee et al. (2016) studied 5D BIM practicality and identified restrictions in different stages of BIM. These results are described in Table 1. The study expects that considerable amount of information can result in complexity, which is displayed mainly during data processing by interested subjects [9].

| Stage | Process | Criteria          | Observation                        |
|-------|---------|-------------------|------------------------------------|
| MODEL | Collection and Input of Building Information into 3D Model | Modelling effort | Neutral |
|       |         | Inter-operability | Poor                               |
|       |         | Information output| Good                               |
|       |         | Limitation        | Non BIM-capable stakeholders will face obstacles in proceeding to stage 2. |
| COST  | Input of Information | Modelling effort | Good                               |
|       |         | Inter-operability | Neutral                            |
3.2. Overview of software applications

Computer and software have raised productivity and speeded up the processes. Civil engineering market realizes justness of eliminating errors caused by incorrect making of bill of quantities; these errors are subsequently transferred to pricing. Based on these facts, several software applications supporting creation of calculations, budgets and a bill of quantities were developed. The USA is a pioneering country in production of these applications; it developed for example INNOVAYA Visual Estimating Software, Vico Cost Planner and Synchro Software. In Europe there are being developed mainly in the United Kingdom (Exactal COST X) and Germany (Nevaris Nemetschek and iTWO 4.0). Overview of software applications supporting creation of calculations, budgets and a bill of quantities in BIM environment and their usage in countries can be seen from Table 2.

| Software application                  | Company         | Use in countries                                      |
|--------------------------------------|-----------------|-------------------------------------------------------|
| Cubit Buildsoft                      | Australia       | Australia, New Zealand, the United Kingdom, Ireland   |
| Nevaris Nemetschek                   | Germany         | Germany, Switzerland, Austria                         |
| Exactal COST X                       | The United Kingdom | Worldwide (Europe – the United Kingdom, Ireland)       |
| INNOVAYA Visual Estimating           | The USA         | USA                                                   |
| BIM estiMate                         | Poland          | Poland                                                |
| Vico Cost Planner                    | The USA         | Worldwide (Europe – the United Kingdom, Sweden, Asia, Australia) |
| Gala Construction Software           | Croatia         | Croatia                                               |
| iTWO 4.0                             | Germany         | Austria, Cyprus, the Czech Republic, Denmark, Germany, Slovakia, Spain, Switzerland, the United Kingdom, Ireland |
| Synchro Software                     | The USA         | Worldwide (Europe – the United Kingdom)               |
| Calcus                               | Norway          | Norway                                                |
4. Implementation of 5D dimension in the world

BIM is not a complete novelty on the market, which can be documented by its raising state of implementation in civil engineering industry. During recent years, great acceleration in BIM usage in practice can be observed. The main reason is the increase in the development of software tools that offer more and more functions for better processing of BIM models. Many countries have implemented BIM in their laws and standards and the research into the state of BIM implementation has been applied [10].

In 2011 in the United Kingdom, National BIM Survey - NBS realized a study focused on finding whether BIM is a way to process buildings design in the future. Following the study, 78% of civil engineering respondents trust BIM’s potential in design processing, while 31% has already used it, that is a growth by 18% compared to 2010. NBS also focused on advantages of the BIM implementing. Respondents stated mainly advantages related to coordination (80%) and lowering of total costs (by 65%) [10].

In the end of 2016, Software Advice (United Kingdom) analysed small and medium enterprises and their needs in construction software. Survey showed that 60% of users look for options of costs estimate software and 24% of respondents want to increase transparency and project level of monitoring. However, 50% still use manual methods for costs calculation, contracts preparation and project management [11].

Research also focused on reasons for implementation of construction software in organizations. They try to accept software solution mainly for:
- Expanding of organizations – if an organization grows, number of work places raises and it must be effectively managed,
- New people – with organization’s growth, new company which needs standardization of processes comes,
- Faults (objections) – for minimizing the risks, growing company has to find effective way to manage their projects [11].

Robert Eadie et al. conducted research called BIM Implementation throughout the UK construction project lifecycle: An analysis. According to the results, software tools supporting information modelling of buildings were used mostly in the design (54.88%) and occasionally in realization (Figure 1) phases. Information modelling is often used in process of pricing and detail design in 51.90% of cases, occasionally in 39.24% cases and only 8.84% did not use it at all [12].

![Figure 1. Use of BIM software tools](image-url)
Findings from Australia and New Zealand are also interesting. In Australia a working group consisting of several governing organizations was established, with organization building SMART ahead, which focused on the issue of BIM implementation. Organization Masterspec (New Zealand) conducted national BIM (New Zealand) survey which found out that the proportion of BIM users increased from 34% (2012) to 57% (2013), with a year-on-year increase in overall BIM awareness in the construction industry, from 88% (2012) to 98% (2013) [13].

5D BIM is rarely implemented in New Zealand. A recent survey of 20 quantity surveyors in New Zealand found out that almost all respondents experienced less than 5 projects which used 5D BIM [14]. Despite of the BIM benefits, the adoption of 5D BIM in New Zealand and Australia is not significantly progressive due to a number of barriers limiting its implementation within the industry [13, 15].

In 2014, Smith conducted a research called BIM and project cost management – implementation issues and creative solutions. Results revealed that there were considerable implementation issues. Following the research, technology has been constantly developing, but work result through BIM technology is still uncertain, while costs for securing the software and training present financial and time difficulty. Breaking discovery is a fact, that standards and support of software compatibility have still not been defined, which causes a problem in BIM model quality or information sharing. Organizations were using mainly Exactal CostX software, but they used it for automatic processing of amount and bill of quantities respectively [16].

The Scandinavian region has had a strong BIM development and implementation track record. In publication Implementation of BIM, Jóhannesson focused on comparing implementation of BIM in Iceland and in the Scandinavian countries. Jóhannesson focused on using BIM in various fields, for example marketing, facility maintenance, cost estimation and scheduling. BIM rate of usage in cost estimating is higher in Scandinavian countries by 14%. Tendering and quantity take-off data is interesting as well. Also in this case Scandinavian countries,– tendering 9% and quantity take-off 18% are in the foreground (Figure 2) [17].

In the Czech Republic, government approved document “Conception of BIM implementation in the Czech Republic” on 25th September 2017. Conception includes a Plan of BIM gradual implementation in the Czech Republic in years 2018-2027, where the most important date is 2022, when it is assumed, that regulation of obligation of BIM usage for over-limit public contracts for construction works financed from public sources will become effective [18]. In the Czech Republic, the field of pricing and facility management is still far from practical usage of the BIM method, mainly for the reason of absence of technical standard information included in 3D model. Currently BIM is used only for 3D models, but there are some attempts to implement BIM into BEP (BIM Execution Plan) contracts and gradually use and solve basic BIM processes and methods [19]. In the Czech Republic, software applications INFO Power, Kros 4 and Polar which contain unique Price URS system are used for cost estimation [20–21].

Nowadays, several specialized types of software for pricing and calculation of civil engineering production are available for users on the Slovak market, while the most frequently used software is

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**Figure 2.** Use of information modelling of buildings – comparison of Iceland and Scandinavia [17].
Cenkros, Kalkulus and Odis. State of its implementation in Slovakia is at the beginning. A research was carried out in 2015 and showed alarming statistics in the level of Building Information Modelling implementation:

- 66% addressed companies did not plan to implement BIM in next 5 years,
- 25% respondents know BIM benefits, however, they did not plan to use BIM,
- 65% respondents did not know BIM,
- And other [22].

Interesting findings about the state of implementation of BIM in Slovakia were brought by the research realized by Mesároš et al. (2016), focused on identification of approaches to cost management in the Slovak building companies. This research showed the influence of using BIM for cost reducing in small companies. The main reason, due to this group of authors, was that BIM technology is mainly used by designers who represented small companies in this research [23].

In 2017, Mesároš and Mandičák carried out research called Exploitation and Benefits of BIM in the Construction Project Management. Research brought the following results:

- 75.29% companies do not use BIM,
- 24.71% respondents use BIM technology in construction project management,
- 89.34% led to cost reducing in construction project management,
- 87.56% led to increase in the quality of the document and the elimination of errors in the project documentation,
- 75.36% led to increase in financial control,
- And others [24].

In the beginning of 2018, a pre-research on current state of BIM implementation in building production pricing was carried out in Slovakia. Within survey, 350 organizations were addressed, while the return was about 15%.

Cost managers were main target group of the survey. Pre-research brought the following results:

- 77.4% addressed do not use BIM tools,
- 67.7% did not meet BIM tools,
- the most widely used tool for a cost estimate is Cenkros (87.1%), but it is not a BIM software solution,
- 12.9% use BIM tools, but only for bill of quantities and only 6.5% use BIM for bill of quantities and the budget itself.

5. Conclusion
Integration of BIM technology and cost management is desirable in civil engineering. BIM technology brings a lot of functions and presents a very useful tool for production and costs management. Many companies do not consider these benefits important and do not see efficiency in using of BIM software applications, but it is only a matter of time, before they succumb to the pressure from a company, which requires more prompt, more effective and more precise assembling of the bill of quantities and setting the prices of a building. Several countries have implemented BIM into its civil engineering industry through laws or it is going to be implemented in next years. Research is more and more focused not only on condition of implementation, but on options of improvement for managing and planning each stage of building life cycle, with emphasis on economical and cost aspect.

Slovakia and the Czech Republic are aware of the BIM potential. Currently, software that does not support BIM is used mostly in the Slovak and the Czech Republics for cost estimating of the civil engineering production. Used software applications contain databases with informative prices, which are structured by integrated classification system of civil engineering production (i.e. CENEKON, ÚRS).

The ambition for implementing BIM into the standards is exerted increasingly. The goal of BIM implementation into cost estimating process is to bring a new view on feature classification. Based on these facts and realized research, 5D dimension is an important part and a decisive tool in construction realization of buildings through the whole life cycle. The main conclusion of the research is that the
selected countries have a different degree of 5D BIM implementation. Slovakia does not belong to the pioneers in the process of BIM implementation compared to other advanced countries.

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References
[1] Kreider RG and Messner JI 2013 The uses of BIM - classifying and selecting BIM uses (Penn State University)
[2] Lu W, Peng Y, Shen Q and Li H 2013 Generic model for measuring benefits of BIM as a learning tool in construction tasks Journal of Construction Engineering and Management 139(2) pp 195–213
[3] AXD studio From 3D to 5D- All the BIM dimensions. AXD portfolio Available at: http://www.axdstudio.com/portfolio/all-the-bim-dimensions/
[4] KROS 2017 Ako správne a objektívne oceniť stavebnú zákazku Available at: https://www.kros.sk/blog/ako-spravne-a-objektivne-oceniti-stavebnu-zakazku-65308
[5] Biolek V, Hanák T and Marovčík 2017 Data Flow in Relation to Life-Cycle Costing of Construction Projects in the Czech Republic IOP Conf. Series: Material Science and Engineering 245 072032
[6] Černý et al. 2014 Návaznosť informačných modelovaní budov (BIM) na smernici Evropskeho parlamentu a rady 2017/24/EU [online], available at: http://xbim.cz/wp-content/uploads/2016/03/CzBIM-Koment%C3%A9%C5%99-sm%C4%9Brnice-EU-v1.pdf
[7] Funtik T. 2015 5D BIM - Piaty rozmer modelu tvoria financie. Eurostav no. 9, 2018, available at http://povodna.bimas.sk/clanky/16/5d_bim_piaty_rozmer_modelu_tvoria_finance
[8] Lee X S, Tsong W and Khamidi M F 2016 5D Building Information Modelling- A Practicability Review MATEC Web of Conferences 26 pp 2–7
[9] Černý M et al. 2014 BIM Príručka-Odborná rada pro BIM o.s. ISBN 978-80-260-5297-5. Available at https://issuu.com/rozpoctakacallida/docs/bim-prirucka-4projects
[10] Gobau T 2016 Construction Software Trends of 2016: Retrospective. Aproplan blog [online], available at: https://www.aproplan.com/blog/efficiency/retrospective-2016-construction-software-trends
[11] Eadie R, Browne M, Odeyinka H, McKeown C and McNiff S 2016 BIM implementation throughout the UK construction project lifecycle: An analysis Automation in Construction 36 pp 145–51
[12] Masterspec. New Zealand National BIM Survey 2012 Available at http://www.masterspec.co.nz/news/reports-1243.htm
[13] Boon J and Prigg C 2012 Evolution of quantity surveying practice in the use of BIM – the New Zealand experience Management of Construction: Research to Practice Proceedings, Joint CIB International Symposium of W055, W065, W089, W118, TG76, TG78, TG81 & TG84 pp 84–98
[14] Harrison C and Thurnell D 2015 BIM implementation in a New Zealand consulting quantity surveying practice International journal of construction supply chain management 5(1) pp
[16] Smith P 2013 BIM & project cost management – implementation issues & creative solutions *Diamond Congress Ltd. Proceedings Creative Construction Conference* pp 744–56

[17] Gobau T 2017 Project cost Estimation: A Practical Guide. Available at https://www.aproplan.com/blog/efficiency/project-cost-estimation-practical-guide

[18] Fibiger J 2017 Stavebnictví 4.0. Available at https://stavba.tzb-info.cz/15752-stavebnictvi-4-0

[19] Slanec M 2017 Koncepce zavádění metodiky BIM v České republice Available at http://www.bimfo.cz/Aktuality/Co-obsahuje-Koncepce-zavadeni-metody-BIM-v-CR.aspx

[20] Zabranský J 2018 Ceny ve stavebnictví Available at https://cinnos;ti.urspraha.cz/zakladni-cinnosti-spolecnosti/ceny-ve-stavebnictvi/

[21] Cegra. 2017 BIM dostal v Česku zelenou Available at http://www.cegra.cz/4-novinka-1182-bim-dostal-v-cesku-zelenou.aspx

[22] BIM crunch 2015 Report: 66% Slovak construction companies not planning to use BIM over next 5 years Available at http://bimcrunch.com/2015/12/report-66-of-slovak-construction-companies-not-planning-to-use-bim-over-next-5-years/

[23] Mesároš P, Selín J and Mandičák T 2016 *Identifikácia prístupov k riadeniu nákladov v slovenských stavebných podnikoch* (Košice: Technická univerzita v Košiciach) pp 195–8

[24] Mesároš P and Mandičák T 2017 Exploitation and Benefits of BIM in Construction Project Management *IOP Conf. Series: Materials Science and Engineering* 245 062056