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Innovative research projects in the field of Building Lifecycle Management

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Abstract

In the era of the great development of information technologies and telecommunications, a natural need to develop and implement a unified system of digital building information modelling has arisen. The rapid development of design technology in the field of architecture, engineering and construction leads to the continuous adaptation of the conceptual apparatus for building information modelling (BIM). BIM technology adopts a new definition as a universal tool for describing various elements of intelligent virtual 3D model of a building combining a series of sequential steps related to the investment, such as requirements of design, construction, operation and demolition optimizations and preparations. In the paper, the authors propose directions of research in the field of BLM (*Building Lifecycle Management*).

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Keywords: BIM (Building Information Modeling); BLM (Building Lifecycle Management)

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1. Introduction

In the age of the rapid development of information systems in the construction sector as well as in manufacturing engineering and service engineering there arises a natural need to develop and implement a coherent system of digital information modelling [11]. This is the second stage of the development of the applied information systems. The first stage concerned setting up of systems of automated design of separate (technological, economic, organizational) processes in various areas of activity (construction, industry, services, etc.) [13] [14] [15]. Selected information systems and automated design systems include elements of artificial intelligence. That has significantly expanded the capabilities of such systems providing the effective operational methods and mathematical models that map the analyzed processes are put in place [16].

Several European countries have been focusing on the BIM development of (*Building Information Modelling*). Danish government has been sponsoring a "Digital Construction" project since 2003. For more than 10 years Finland, Great Britain, Netherlands, some other EU member as well as Norway, US and Australia have been developing national initiatives aiming at implementing digital modelling in construction. They undertake actions under the "Building Smart" theme, which includes the development and coordination of classifications, standards, data exchange formats, uniform public procurement requirements and the accompanying ICT technologies. Joint initiatives of business, educational institutions and governments in the area of "digital construction" aim at designing integrated and coherent digital modelling systems so that all information encapsulated in a construction project could be utilized throughout the whole building life cycle, from its concept until the demolition [17].

In the article, main ways for further BLM methodology development is analyzed (*Building Lifecycle Management*). Further development of these issues requires a lot of effort and can be the subject of a research project.

2. Evolution of Building Lifecycle Modelling

In recent years, efforts have been made to transform the traditional three-dimensional BIM into a four- (4D) [5], five- (5D) or even six- (6D) and seven-dimensional (7D) version on the basis of the application of PLM (*Product Lifecycle Management*) to construction [8][2][9]. This solution has been named BLM (*Building Lifecycle Management*) or unified project management (figure 1) [4].

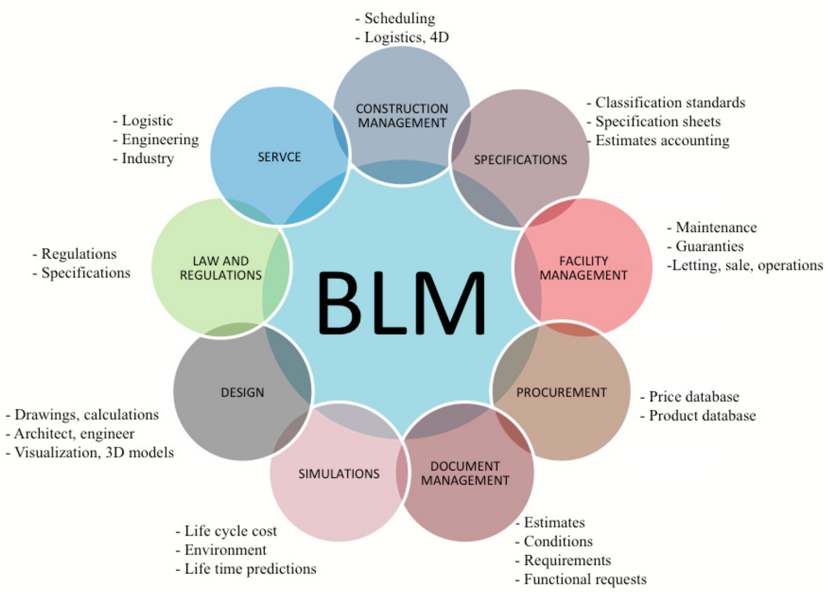

Fig. 1. BLM lifecycle view

The described trend may be seen as a logical consequence of utilising large amounts of information available in a 3D building model [1]. 4D, 5D and 6D BIM technology may be described as:

- 4D – virtual building model with construction plans and work progress control capability accompanied by the visualization of a virtually constructed building in a given moment in time;
- 5D – enables a precise cost estimation and eliminates errors made by a person preparing the estimation;
- 6D – Introduction of sustainable development principle into the investment process. Thanks to this technology, various options (e.g. utilization of solar energy) can be evaluated already in the building concept phase.

The latest trend in BLM implementation may be labelled as 7D modelling. It is based on the Facility Management concept. In this concept, the management of a building encompasses its full life cycle from the concept up to the demolition. Integration of many layers of building design allows analysing problems and phenomena, which until now were beyond the scope of the building design process.

In order to summarise the terminological deliberations one may describe BLM as a way of: a) developing a strategy of a construction project, design, construction, management based on modelling, computer simulation of the object and on its full lifecycle [7], b) providing a mechanism of an integrated management of graphical data and information flow in connection with the process description in the framework of an integrated IT environment; c) transforming separate contractors into teams, and decentralisation of an instrument of solving complex problems and of the integration of separate tasks into processes; d) quick, more effective and less costly implementation of such operations in the whole construction project lifecycle [6] (figure 1).

Currently it is very important to develop the BLM methodology. It will be the basis of the intelligent e-city were all the processes (construction, infrastructure, engineering, logistics, engineering services etc.) are based on the developed information models. This means that they are easily modelled, optimized, managed and archived.

The total integration of the building with the environment that surrounds it is referred to as the federated approach in the virtual world (figure 2).

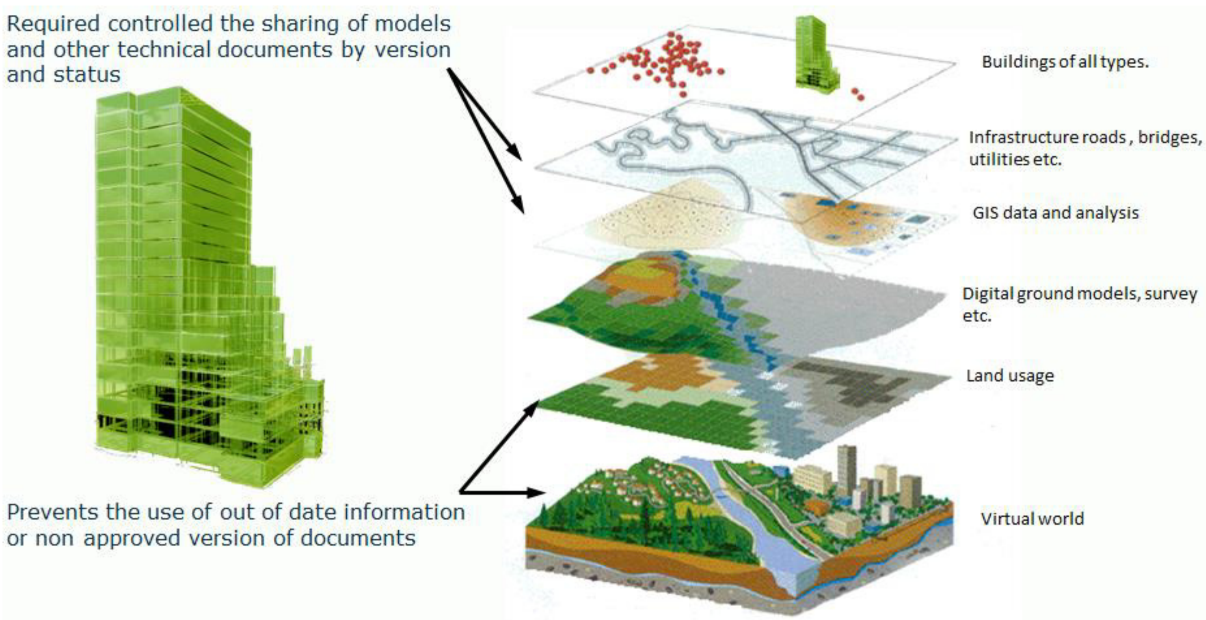

Fig. 2. The concept of the virtual world

3. Proposed directions of scientific projects in the field of BLM

It must be considered that the implementation of BIM and later BLM methodologies require a lot of expenses (especially at the state level – development of the relevant standards, classifications, database of the appropriate level, the upgrade of the servers and computer networks to transfer the required amount of information and so on.). Therefore, this level of the investment process is impossible without the effective implementation of the BLM model. It is obvious that the greatest effect could be achieved by making effective decisions. In turn, the most effective solutions are possible by using the artificial intelligence models.

Based on the analysis of the state-of-art research and practice in the field of BLM the authors propose the following directions of research projects.

3.1. Efficiency Assessment Model for Building Lifecycle Management

After the analysis of various sources, it could be concluded that currently there are no mathematically justified and reality-corresponding efficiency evaluation methodologies for Building Lifecycle Management (BLM) on the construction market. Only vague effectiveness evaluation throughout the life of a building may be observed. The absence of a methodology based on mathematical models has also been observed.

The scientific problem defined by the authors consists in determining the effect of BLM methodology in all processes of the building life cycle, starting from the idea of building (construction investment project) and to the end of the operation of the building. The proposed scientific goal of a research project is to create a model for assessing the effectiveness of BLM (Building Lifecycle Management) based on the experience of European countries and the USA, and empirically approve it by creating a classifier.

The project would develop as a result the Building Lifecycle Management (BLM) efficiency evaluation methodology. The developed methodology would allow the classification of BLM implementation feasibility and usefulness for the project, depending on the buildings' parameters. Following detailed hypotheses might be tested:

- H1. The use of BLM methodology in all processes of the project life cycle has an impact on: the urban and architectural efficiency and economic evaluation processes; acceleration of the development of the construction investment project/design; errors reduction in the construction project; the accuracy of building energy assessment; the level of digitization of the design process; the level of integrity of the design processes; the quality of the data exchange between participants in the design process; and between the participants during the construction process, process production engineering, process engineering of services
- H2. The use of BLM methodology in all processes of the project life cycle has an impact on the efficiency of the construction, production engineering process and economic assessment, and measuring by reduction of errors/defects, the accuracy of construction and production work, the absence of delays during construction and production engineering.
- H3. The use of BLM methodology in all processes of the project life cycle has an impact on the effectiveness of the management of the construction, production engineering processes and economic assessment, and measuring by achieved level of the process indicators, completeness of technical, economic and legal information.
- H4. The use of BLM methodology in all processes of the project life cycle has an impact on the effectiveness of the processes of construction, and facility management as well as the economic evaluation, and measuring by extending the life-time of the building, by improvement the quality of life for the building users, by completeness level and the availability of technical information for the purposes of exploitation.

The contribution to the body of scientific knowledge would consist in the formulation of a mathematical model and of a model-based classifier. The methodology of assessing the effectiveness of BLM developed in the framework of the proposed project might be used to classify buildings according to the necessity and priority of the application of BLM. Priority application is important due to the insufficiency of resources and the inability to implement BIM method to all buildings at the same time. The developed methodology for assessing the effectiveness of the methodology of BIM might be used in the future to justify the development of BLM.

3.2. Development of fundamentals of artificial intelligence in Building Lifecycle Management

The concept of another research project related to BLM derives from the following scientific problem: how to determine the impact of the application of artificial intelligence of BLM methodology at all stages of design (construction investment project, architecture, construction, technology and organization, production engineering, management, economics etc.) in all processes of the building life cycle, starting from the idea of building (construction investment project) and to the end of the operation of the building.

The scientific goal of the project could be formulated as follows: to develop the fundamentals of artificial intelligence in BLM at all stages of design (construction investment project, architecture, construction, technology and organization, manufacturing engineering, management, economics etc.) in all processes of the building life cycle, starting from the idea of building (construction investment project) and to the end of the operation of the building.

The main hypothesis of the project could be formulated as follows: a mathematical model could support the artificial intelligence methodology applied to BLM on all stages of the building design (architecture, construction, mechanical engineering, electrical engineering, manufacturing engineering, service engineering, construction technology and organisation, management and economics) in all processes of a building lifecycle from the concept up to the end of its operation.

The following research tasks are foreseen in the project:

- Characteristics of the effectiveness of the BLM methodology in scientific literature.
- Characteristics of the effectiveness of the artificial intelligence methodology in scientific literature.
- Development of the framework for integrating artificial intelligence into BLM in the design stage (architecture).
- Development of the framework for integrating artificial intelligence into BLM in the design stage (construction, mechanical engineering, electrical engineering).
- Development of the framework for integrating artificial intelligence into BLM in the design stage (manufacturing engineering, service engineering).
- Development of the framework for integrating artificial intelligence into BLM in the design stage (construction technology and organisation).
- Development of the framework for integrating artificial intelligence into BLM in the design stage (management).
- Development of the framework for integrating artificial intelligence into BLM in the design stage (economics).
- Identification of main groups of factors (indicators) directly influencing the efficiency of an investment project in BLM on the level of artificial intelligence.
- Development of the framework for integrating artificial intelligence into BLM in relation to all stages of a project lifecycle.
- Creation of a system of statistical indicators for the monitoring of efficiency and effectiveness of the artificial intelligence application in BLM.
- Empirical validation of the proposed level of artificial intelligence and the assessment of BLM effectiveness through the creation of a classifier and determination of the assumptions for the implementation model based on the European and US experience.
- Synthesising the recommendations and instructions.

It is necessary to consider the main tasks of artificial intelligence at all stages of the design:

- the exact definition and classification of the item (element) that will be selected for a detailed analysis,
- selection of the methods, suitable for the selected item analysis,
- direct analysis of the indicated element,
- Data wording and transfer for the subsequent design phases.

The main result of the project and the project's contribution to the body of scientific knowledge would be an algorithm of the artificial intelligence in BLM on all stages of the building design in all processes of a building lifecycle from the concept to the end of its technical life.

4. Conclusions

Information and data gathered from various case studies allow to point at the potential benefits resulting from the BIM concept implementation (in the second phase of BLM). The experience of project participants led to the definition of the decision making process prior to BLM implementation and to the recommendations concerning the BLM process planning in small enterprises with different software and working methodology. BIM implementation urgently requires the development of reliable data exchange tools for the users of diverse software. Such tools would enable the effective direct coordination and process monitoring among project participants and team members. Standardisation of working methods is necessary for the BLM concept popularisation.

In the proposed research projects, the methodology of assessing the effectiveness of BLM (Building Lifecycle Management) can be used to classify the buildings according to the necessity and priority of the application of BLM. The artificial intelligence algorithm designed for each stage of the building design (architecture, construction, technology, organisation, management and economics) and of the building lifecycle (from design to the end of building use) may be used to enhance the whole BLM process.

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