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Challenges of BIM technology application in project planning

Leonas Ustinovičius, Arūnas Puzinas, Jovita Starynina, Mantas Vaišnoras, Oksana Černiavskaja, Robertas Kontrimovičius

Corresponding author:

Leonas Ustinovičius

Vilnius Gediminas Technical University, Faculty of Civil Engineering, Lithuania
e-mail: leonas959@gmail.com

Arūnas Puzinas

Vilnius Gediminas Technical University, Faculty of Civil Engineering, Lithuania
e-mail: apuzinas@yahoo.com

Jovita Starynina

Vilnius Gediminas Technical University, Faculty of Civil Engineering, Lithuania
e-mail: jovita.cepurnaite@gmail.com

Mantas Vaišnoras

Vilnius Gediminas Technical University, Faculty of Civil Engineering, Lithuania
e-mail: mantas@esco.com

Oksana Černiavskaja

Vilnius Gediminas Technical University, Faculty of Civil Engineering, Lithuania
e-mail: cerniavskaja@gmail.com

Robertas Kontrimovičius

Vilnius Gediminas Technical University, Faculty of Civil Engineering, Lithuania
e-mail: rkontrimovicius@gmail.com

ABSTRACT

The study aimes at identification of the difficulties in choosing the correct concept of the main building process. The use of a proper BIM design may help the user avoid mistakes and make the building process faster as well as less financial resource intensive. The authors focused on literature review, analysing the difficulties of the BIM design software technology in construction project planning. The biggest flaws in BIM design are inherent in three building process stages: 1) the preparation of a building investment project, and the analysis of the existing situation; 2) the preparation of the building execution technology project; 3) the existing standard processing and information collection in building exploitation period. The analysis shows a persistent need for a deeper BIM design research, to improve information interchange formats that would ensure as much design information saved as possible with ensured feedback. As well as in BIM design, the software packages must be improved by supplementing them with deficient tools or programme codes. After the research of BIM design software, it was determined that architectural, constructional and MEP programs work best interdependently and get analysed the most. These programs work best as they make the least number of mistakes when the model is created in one setting and has many tools. This type of design software data is kept internally, and they are converted into IFC or other information interchange format. Without changing the format, the data is not lost, and this is the reason behind fluent information interchange.

KEY WORDS
BIM, project, building process, difficulties

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Introduction

The building sector, which contains the unconventional building process BIM (Building Information Modeling), is undergoing rapid growth across the world. The linear projection and building management structure could be considered the conventional building process model. In this model, it is possible to segregate projection, planning, realisation and exploitation stages (Fig. 1). The building process based on the BIM method is an unstoppable cycle where stages of the building process and information stream management are prepared as an organisational activity system, at the same time considering transitional design decisions and the final result, which is used for the exploitation and management of the final result after the building process is finished (Fig. 2).

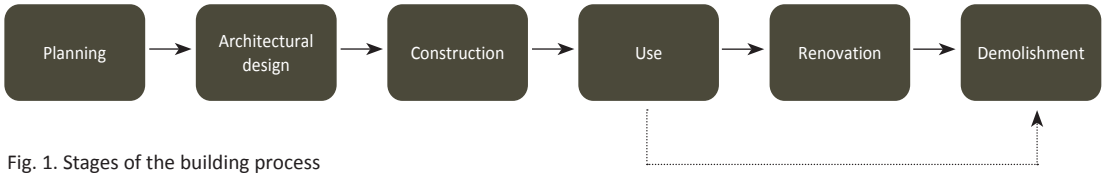


Fig. 1. Stages of the building process

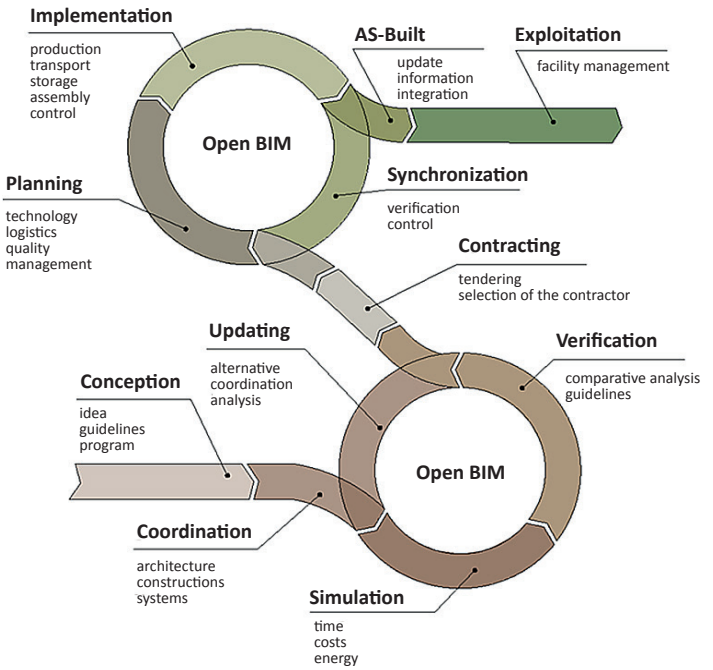


Fig. 2. Building process using the BIM method

The authors of the article (Bryde et al., 2013) carried out an analysis regarding the benefit of using BIM during the design stage. It was determined that the use of BIM has obvious advantages, yet it can be rather unaffordable to some users. Representatives of the construction industry base their decisions to invest in BIM on its expected impact on the construction project performance (Reizgevičius et al., 2018).

The BIM technology (the future technology of the constructions (Harris, 2013)) would help address such issues as high costs, terms of the construction process, life cycle, and design model construction management. BIM is one of the most promising recent developments in AEC industry (Azhar, 2011). According to Talapov (Талапов, 2017), BIM includes more lifecycle phases, integrates program controls, and standardises information management making meanings clear and consistent. It is an additional model for an engineering information database of a project, storing all the architectural designs with geometric information and the corresponding technical information of all work (Ding et al., 2012). The ability to import data on buildings from BIM saves time and reduces uncertainty in building energy modelling process. BIM technology is significantly more labour-intensive compared to a traditional design model. In recent years, efforts have been made to transform the traditional three-dimensional BIM into a four- (4D), five- (5D) or even six- (6D) and seven-dimensional (7D) version based on the application of PLM (Product Lifecycle Management) in the construction sector (Ustinovičius et al., 2015). The 4D technology allows the construction planner to produce the more rigorous schedules (Heesom & Mahdjoubi, 2004; Migilinskas et al., 2013).

Users may avoid mistakes by choosing the appropriate concept of the main building process and using the suitable BIM design (Reizgevičius et al., 2015). This way, the building process becomes faster and financial costs can be reduced. The result of a geo-

metrical design is a model, which is the object of modelling and depends on the chosen geometrical parameters, such as realisation span, expenses, etc. Model BIM facilitates the efficient and automatic creation of some documents, such as data statements, expenses and calendar schedules (projection in 4D and 5D settings) (Tomana, 2016), and substandard tools, such as management of design amendments (Juszczyk et al., 2016; Migilinskas & Ustinovichius, 2006). There are rules in the BIM method that help in the process of integrating human resources connected to building investment projects (Tomana, 2016), in which the main attention is given to organisational and legal aspects in the building project management. BIM allows exploring and optimising various qualitative, financial and graphical aspects while modelling a building. This ensures productivity and more precise predictions that are necessary for productive coordination of various disciplines and creation of optimum workforce. The literature analysis suggests that pieces of design software developed by the same producer interact the best. In these programmes, a fluent information alternation process is ensured, where there is no need for an extra format for information transfer and work is performed in the same model by connecting various tools. These types of programs interact well and, upon selection of an option, can provide feedback when the exported model could be supplemented with information from some other discipline, contained in a different piece of design software; besides, the previous version can be restored without losing the modelled information (Fig. 2).

Nowadays, BIM is used in the building process as combined design software. It is used widely, although the usage of BIM does neither secure a consistent cyclical design nor its use because of several reasons:

- the present BIM design software does not provide common, consistent feedback (i.e. for each stage to be performed, the present BIM design software does not have a common format in most cases; in the process of information transfer from one design software to the other, detailed data may be partially lost);
- some BIM design software does not have a common format for information distribution;
- some fields do not have BIM design software;
- single BIM design software is very expensive;
- users are not able to maximise on the use of all possible options of design software.

To create an efficient building process by uniting all the parts in the BIM setting, it is necessary to set up proper criteria and their order. It is essential to apply the criteria properly, so as the project realisation/creation process would be held as a process analogical to the production (planning and realisation) by using the controlling methods and production quality. In general, the evaluation of investments and the risk analysis are performed in the design stage (through an efficient variant selection). In this version, the planned management actions are performed in a way that the design requirements would be fulfilled by assuring constructional, qualitative, term accomplishment, and budget conditions. Stages of the main BIM building process are united by the process manager. The transitional stage link information must be systematised and described properly using the criteria and functions. BIM enables the exploration and optimisation of various qualitative, financial and graphical aspects while modelling the building. This ensures the productivity and more precise predictions, which are necessary for the productive cooperation of various disciplines and the creation of an optimum workforce. The review of software developed by the biggest BIM design software producers as well as their advancement determined a construction site as the least explored and unfitted environment for the use of BIM, i.e. many BIM design software developers offer programs for the design of a technological project of a building even though it is not fully automated. During the design, a possibility to create models of 3D mechanism and elements is estimated by describing an algorithm. It is possible to simulate the technological process of certain elements. A single technological process description does not cover the complete construction operation and technology. If the process is not analysed properly, rational, optimal solutions are not achieved. This type of building technology design does not optimise the whole process and does not depict the most relevant process which would be evaluated reasonably considering as many real factors as possible. In the design stage in the BIM setting, a prepared building technological project would ensure a faster and more fluent building production helping to avoid mistakes and staying within the planned time framework and the financial schedule.

The purpose of this article is to review and analyse the unified design, construction and operation of a building on the BIM platform by establishing:

- shortcomings of the existing BIM software package interaction between different applications and information exchange actions;

- setting the BIM software package shortcomings as programs to be able to fill the gaps and make the cyclical design process sequential.

1. Joint BIM system analysis and possibilities

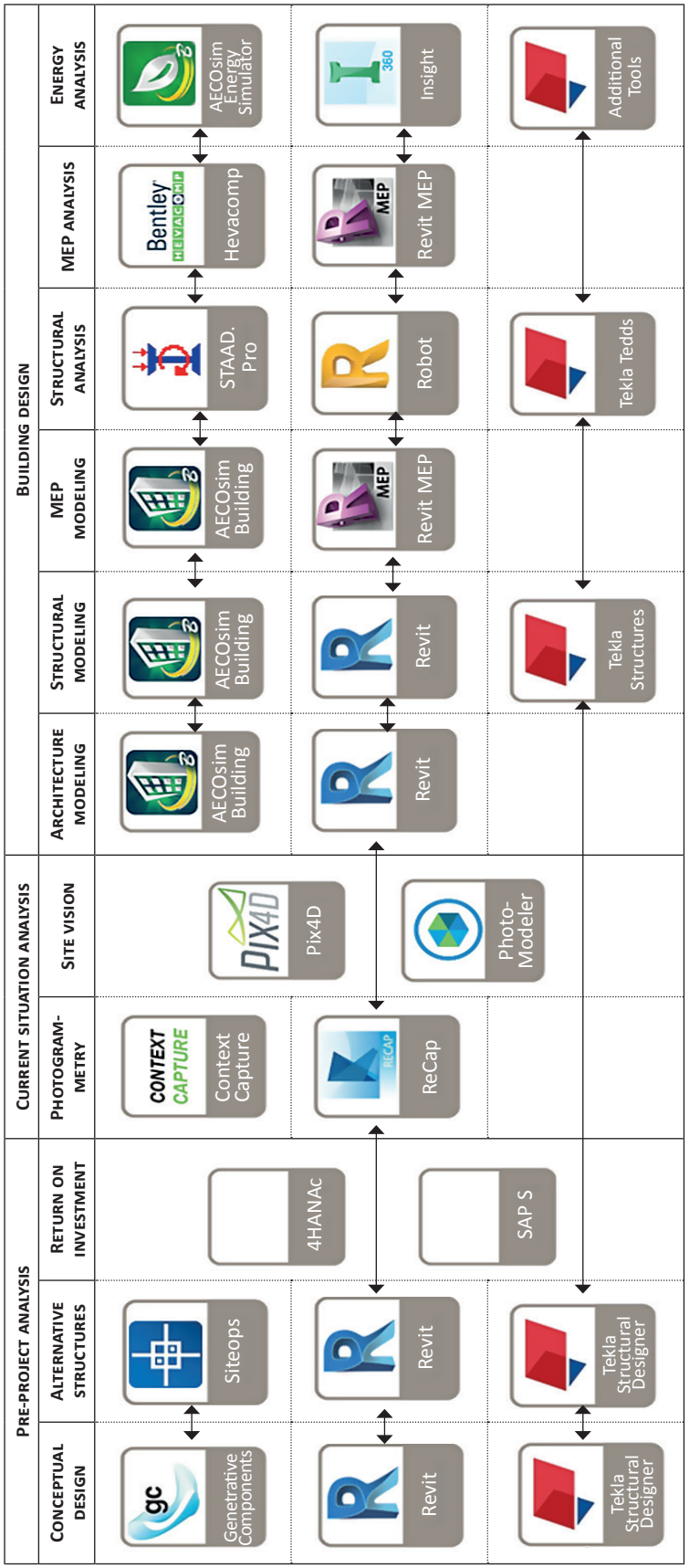
In the study of the disadvantages of BIM systems, the possibilities of BIM packages were analysed by testing their tools in practice and reviewing the literature and program manual. Following the analysis of the existing program reviews and research of their possibilities according to the popularity in the market, three BIM design software producer types were identified: AUTODESK, BENTLEY, and TEKLA. Tab. 1 and Tab. 2 were made based on the analysis of the design software according to their possibilities and areas of use. It was determined that the biggest developers of the BIM software design package do not address the whole building cycle, which is demonstrated in Fig. 2. Based on data, an information interchange map between the programs was created (Tab. 1 and Tab. 2). It was determined that the design software function best when one of BIM packages has more tools and could be used for many tasks without exporting the information to another setting. The analysis of the design software research revealed that in the building process stages building design and project delivery, BIM programs have the widest spectrum of tools that ensure fluent design actions during the stages.

The analysis of the design software map determined that one of the main flaws be the primary ideas for the evaluation using BIM tools. During the building design, the investor's duty is to indicate the project management direction and control it during the whole process cycle by enacting solutions for the project function, shape, budget and the execution term. As well as the expectations and vision of the investors, the project in the stages of building design and exploitation must comply with the standing building standards and rules. To ensure a successful project, all the information must be evaluated at the stage of the primary vision development. One of important example is available from Eastman (2009), namely, an inventory for the design of a primary investment model with the focus on the automation of project stakes so that it would be possible to evaluate and check the proposed primary investment conception according to a certain criterion. A new platform for the BIM investment inspection was created according to a prepared specific criterion, where a described model was uploaded into the system in the IFC format and analysed according to the described criterion and standard requirements. The model complies with the investor's conception, which is checked in the software design with installed BIM tools. These supplementary BIM tools were initiated by the real estate sector to control the risk of investments (Choi & Kim, 2008). It was determined that a proper investment planning using BIM tools requires all the standard documents and requirements would be directly connected to the project to facilitate a thorough project analysis (Greenwood et al., 2010). Hjelseth (2015) described a project evaluation BIM system based on standard documents where standard rules were converted into formulas and data describing rules. This model works properly when the person who designs the model does so according to common system requirements and structure. Ahmed M. Abdel Aziz examined how important economic modelling and risk analysis were for the evaluation of infrastructure and revenue while generating projects such as build-operate-transfer (BOT). The author defines "classifications" of estimating and cash flow methods and develops a summarised model. A classification introduces a particular domain – e.g. construction, revenues, financing, operation and maintenance, or risk analysis – and holds the estimating methods of that domain.

To keep within project budgets, implement programmes, and properly co-ordinate and communicate designs, the design process needs to be planned and controlled. Problems can occur in cases of missing information, poorly communicated information, inconsistencies between documentation, poor resource allocation, poor decision making due to inadequate information, etc. These difficulties have become more prevalent as buildings have become more technical, the range of products and materials has increased, standards and regulations have become more strict, and there is a greater number of specialist designers, particularly in the early stages of the design process.

According to Tab. 1 and Tab. 2, a joint cyclical building process cannot be ensured because of the missing BIM software for automatic building management and building ground. Design tools can be used to visually portray the model of a crane and a chart storage place in 3D dimension. Based on

Tab. 1. BIM design information interchange map



Tab. 2. BIM design information interchange map

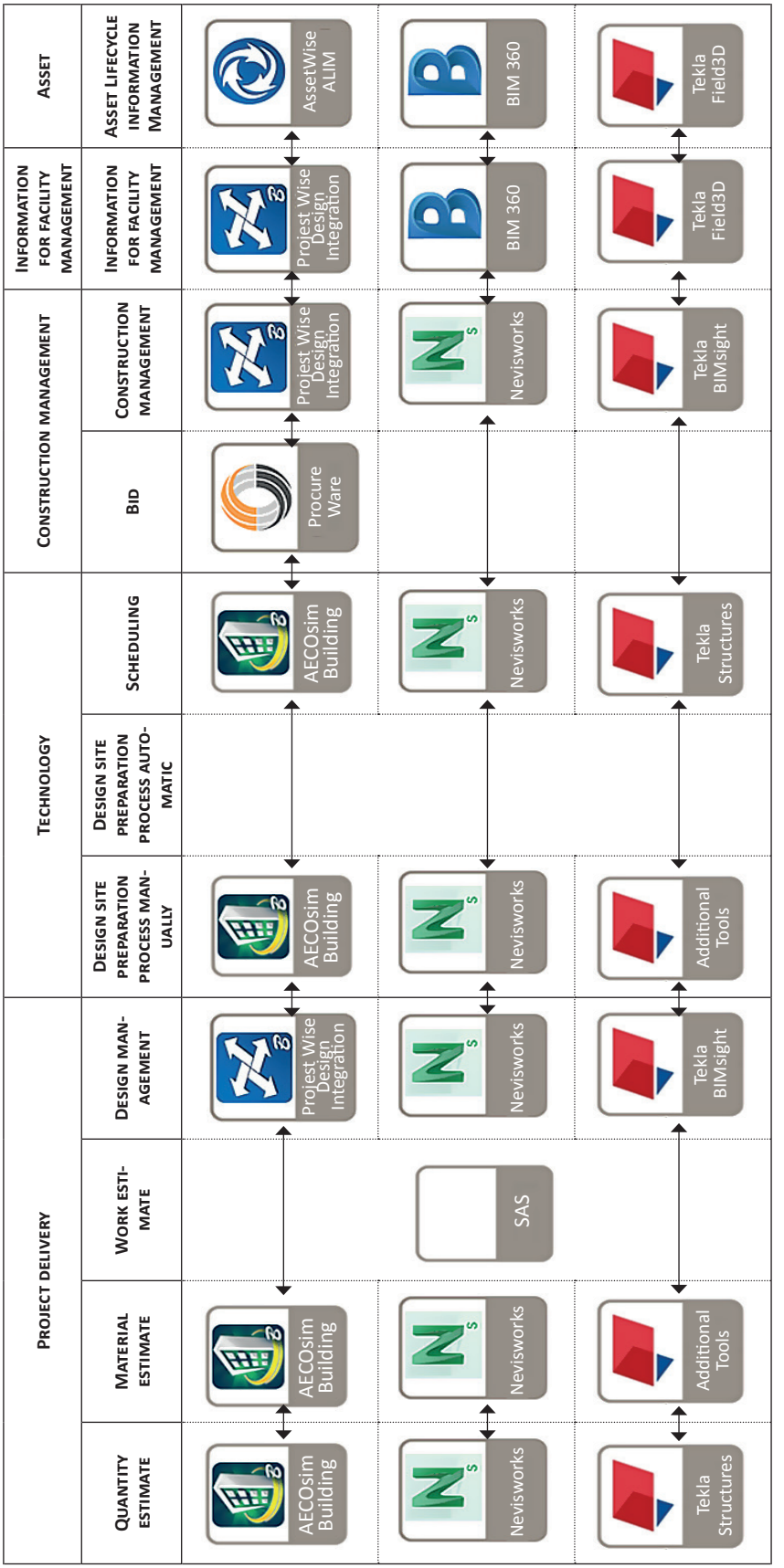


Fig. 3. Main criteria of the most popular program

standard requirements, it is not possible to use BIM design tools to solve building ground preparation tasks (Astour & Franz, 2014). The projectors in BIM setting cannot solve building ground installation tasks, and the results contain many mistakes in comparison to the actual building site. This design must be planned to properly evaluate the construction price and execution period (Tommelein et al., 1992; Rayes et al., 2005). The design of the BIM building process is necessary for the execution of an optimal building plan by analysing all the possible variants and optimising them (Astour & Franz, 2014). It is important to create a large amount of information based on BIM, which would be easily processed and optimised (Trani et al., 2015). Building process management has several stages, including the analysis of the building ground planning and building ground organisation. The organisation part is described using different criteria using BIM, which helps in managing the process and optimising it for all the participants by understanding how the system works in the same way.

Nowadays, it is important to receive timely information and not waste time while searching for documents. Many new pieces of software can help manage and facilitate the building processes.

Bartos researched that high-quality preparation phase of the project leads to the achievement of the defined goals. He also investigated the determination of the project cost using the pricing methods. The author found that automated software helps to model the realisation of construction works for supply creation, preparation and management of the construction process.

Bid Management involves the automated management of bidding for digital marketing campaigns. Bid management tools, also called bid optimisation platforms, enable the automation of small and quick bids for different projects. Bid management is also used to manage bids in the display and market, with the development of real-time bidding. This automated management is possible thanks to algorithms defined by a marketing manager. Sometimes small-size business has time shortage and no recourses for constant monitoring of keyword bids and become the victims of "setting and forgetting" method that causes the loss of money.

One of the most important criteria during construction is the quality of work, billing and invoicing. Martínez-Rojas et al. (2016) described the reason for the dependence of construction projects success on a good access to and management of information. Nowadays, some information is still stored in different databases and even on paper. One of the most important documents in the project management context is the Bill of Quantities. However, a great deal of different types of documents are important in the support of main management tasks.

The author researched that most project information is still stored in different documents and databases and it takes plenty of time while managing all billing and invoicing in every construction. Martínez-Rojas et al. (2016) suggest integrating all this information in a common repository, which is vital for making reliable decisions as well as reducing the time and resources spent to reach these decisions.

Isaac (2017) stated that a considerable proportion of the work in construction projects, as a rule, is

performed by different subcontractors. Therefore, it is very important to commit to an effective work packaging process, which is critical for subsequent implementation planning. Almost all construction projects are made of combined networks of elements and supplies that share numerous interfaces. The author suggested close coordination of subcontractors.

Isaac (2017) studied estimates that around 60 and 70% of the value of a project is typically subcontracted. So, the main gage of handling such interfaces boosts due to the reality that an important sum of the work in construction projects is generally held by subcontractors.

The offered general resolution was to directly qualify work packages according to the building systems in the design, to which components belong, despite the difficulty this produces in planning and managing the performance of such work packages.

Contract management is the management of contracts with the participation of customers, vendors, partners or employees. The personnel involved in contract administration required to negotiate, support and manage effective contracts are often expensive to train and retain. Contract management includes negotiating the terms and conditions in contracts and ensuring compliance with the terms and conditions, as well as documenting and agreeing on any changes or amendments that may arise during its implementation or execution. It can be summarised as the process of systematically and efficiently managing contract creation, execution, and analysis for maximising financial and operational performance and minimising the risk.

Job scheduling includes management of land and permit that are the main parts here. Using these tools, it may be helpful to determine the legal fees for all necessary permits for purposes of the budget and project timeline as early in the process as possible; review the complete package of plans and applications for both compliance with laws and regulations; present the information in the way acceptable to the government agency; and ensure completeness of the information in the package; make a critical review of the submission package to determine if any additional steps are necessary in the submission process, e.g. structural sheets may indicate the need for a critical structure review; prepare comprehensive land and building analysis; prepare and manage all plans ensuring they are signed and sealed; review the size, scope and schedule of documents.

Sobieraj (2017) examined, that most project management methodologies should pay much more attention to project planning. When every stage is scheduled during the project planning phase, the project manager can avoid costly mistakes in the imple-

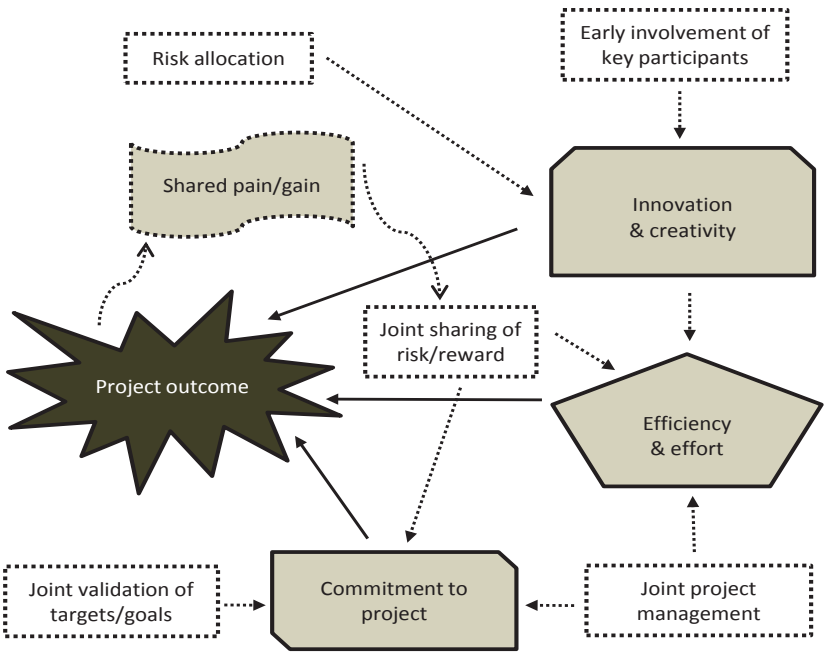


Fig. 4. IPD Structure

Source: (Ashcraft, 2012).

mentation phase. Job scheduling in the initial phase also helps to obviate unnecessary problems and it is possible to realise a project without extra costs.

The author noted the importance of a new innovative approach to the planning process of every project by introducing improvements and innovations.

Lead management is the process of tracking and managing prospective customers. Sometimes, it is referred to as customer acquisition management or contact management. The process of managing leads helps businesses understand, which tactics are bringing in the best results, so it is the way to optimise the sales strategy to be effective and efficient (Ejdys, 2014).

Moreover, since lead management documents a person's full history of interactions and experiences with the company, it becomes possible to analyse exactly how a person was converted from a prospect to a lead and a customer.

Fink (2014) described that a lead manager's competence in a construction project performance is mainly influenced by reaching internal and overall budget, quality and deadline goals. She noted the importance of achieving the final goal and explained how it depends on project manager's skills. By the way, a lead project manager needs help from stakeholders, their business relationships and the whole team. The author emphasised the significance of the timetable and planning as any defects in the initial phases could have extensive effects on the last stages.

In relation to Permit Management, it is important to note the common rule that building permits are necessary to start a construction project. But every jurisdiction has more or less subtle differences in zoning, laws, regulations, building codes, and requirements. It becomes clear when it comes to presenting architectural drawings and plans. These aspects can determine the difference between a project sailing through the process with minor revisions or experiencing major delays. Changes and adjustments to the complex design and construction project are carried out continuously. The design process and conditions are constantly changing; therefore, constant design documentation must be checked against the existing regulatory documents. Due to these circumstances, the entire legal information on the project must be structured and aligned in a suitable format so that the design has no errors.

Online platforms of selection sheets provide a possibility to collect customer data without stress and frustration. Homeowners can log in online to make and approve their selections. Once they are done, contractors are alerted about the newly approved selections and can easily track allowance overages, etc. Online selection sheets may allow:

- setting due-by dates to keep homeowners on schedule for their selections,
- receiving notifications as selections are approved,
- having a conversation in each selection's comment feed,
- transforming approved selections into change order contracts,
- tracking overages and allowance vs. the chosen figures,
- saving selection sheets to templates for future use,
- importing to and exporting from Excel.

Subcontractor Management is the management of outsourced work performed for an individual company. Contractor management implements a system that manages contractor's health and safety information, insurance information, training programmes and specific documents that pertain to the contractor and the owner/client. The majority of nowadays contracts require the effective use of contract management software to aid the administration between multiple parties. Risks increase with the loss of control from outsourcing work. With the ongoing outsourcing of production, companies put a lot of effort into standardising their contractor management processes.

Arashpour (2017) considered that the optimisation of supply decisions enables off-site manufacturers to achieve high production performance with a smaller supply investment. The author also analysed how optimisation of the provided solution under uncertainty is formulated, and cost of adopting multi-supplier configurations to address uncertainty is optimised.

Arashpour explained three research hypotheses mainly on the optimisation of submittal management and configurations are developed and tested. It is very important to realise that the progressive fabrication of building products is not a self-contained work, and cooperation with the provision of networks is always required. According to the author, the complexity and comprehensiveness of supply networks in off-site manufacturing justify this assumption.

Supplier Management. The main key to the effective supply chain is supplier management. It helps to account and optimise supply chain properly. "Suppli-

ers sit at the heart of almost every organisation's activities and processes" (Smith, 2014).

If a company has the vision to run as it should, it must ensure the seamless flow of goods and products.

Shi et al. (2016) analysed how construction supply chain management achieved rapid progress over the past decades. He stated that, as a result, the traditional internet file is to fulfil the demands for real-time information sharing and communication derived from various construction supply chain members. The article by Shi et al. (2016) provides an overview of research methods adopted in the field of construction engineering and management, including survey, observation, case study and experiment.

The author provided the theoretical contribution to the development of an integrated framework in this research domain. He also explained how important it is to fill gaps in the existing body of knowledge and identify the future research.

Task management software helps a company to manage large projects effectively and on schedule. The system helps to generate feasible targets and deadlines in line with the data included in the application. Plus, it can be linked to interdependent tasks for seeing the whole picture and making sure the team deliverables balance out rather than contradict one another. Task management can be used as software to predict problems and opportunities and reorganise the methods and resources according to the changing circumstances. The system can help to achieve the goals and objectives no matter what type of a project. In assigning tasks, it is important to allocate work properly according to available resources. BIM enables these processes to be optimised while minimising human resources. According to the common practice, resource allocation can be done according to an appropriate production plan (Fig. 5).

Kuenzel et al. (2016) presented some methods that promote project task management with real-time communication on the construction site, including processes and performance of machines and staff.

The authors claimed that multi-agent systems remain as a promising practice for automated site task management, which reduces the centralised, strictly hierarchical work portfolio of a traditional site manager.

His article takes over techniques from the range of divided artificial intelligence, namely, multi-agent frames, to promote a method that automatically generates instructions for human operations. The method

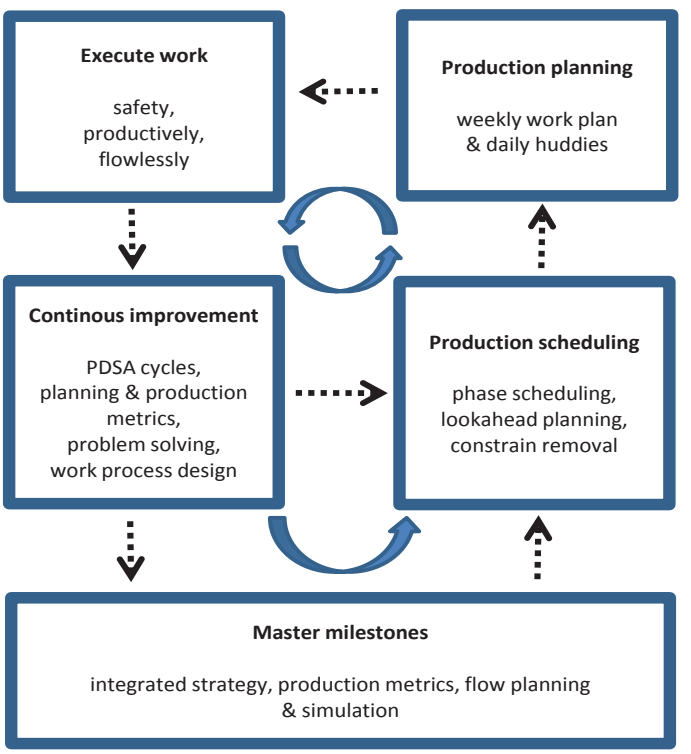


Fig. 5. Production management scheme

Source: (Fisher et al., 2017).

can react to variable and changing site task management conditions.

Service Management delivers integrated work-order management for more efficient processing of service and small job work. Using service management, a company can stay on top of the maintenance work, streamline tracking of equipment maintenance, facilitate renewals and simplify the billing process.

The main goal of high-performance service management is to optimise the service-intensive supply chains, which are usually more complex than a typical finished-goods supply chain. Most service-intensive supply chains require larger inventories and tighter integration with field service and third parties. They also must accommodate inconsistent and uncertain demand by establishing more advanced information and product flows. All processes must be coordinated across numerous service locations with large numbers of parts and multiple levels in the supply chain.

Crnković and Vukomanović (2016) considered how effectively project risk management could help to ensure a significant impact on the success of project goals and lower warranty costs in the future. He also explained how important are knowledge, experience, communication and understanding in all stages of a project. Once construction project is done, it is time for service the management stage.

In conclusion, the authors explained how to establish quality connections between theory and practice to improve the philosophy of risk management by using legal provisions to make risk management an obligation for every Project. These criteria are based on a table of five most popular design programs (Tab. 3).

The literature review revealed that one software package is not enough for designing and analysing the energy efficiency of a building. Gerrish et al. (2017) use the Dynamo program to output data from the REVIT BIM environment to JavaScript Object Notation (JSON). Any information conversions have weaknesses due to the loss of data content and completeness, and there is no complete reciprocal linkage with the results obtained in the original model.

The method using an active BIM model is innovative and may bring significant benefits for building management. Simulations of building behaviour allow designing the appropriate shape of the building as well as the use of relevant materials and engineering systems, ensuring safe and comfortable use of the building in the future. Successful management of any innovation largely depends on identifying the critical determinants of innovation performance.

Benefits identified during the construction phase include less rework, reduction in requests for information and change orders, customer satisfaction through visualisation, improved productivity in phasing and scheduling, faster and more effective construction management with easier information exchange, accurate cost estimation, and visualising the safety analysis (Eastman et al., 2008; Hardin, 2015; Elbeltagi & Dawood, 2010; Azhar, 2011; Hartmann et al., 2012). During the operation phase, this technology includes control of facilities management progress, integrated life-cycle data, rapid and accurate information of updating and changing activities, and more effective facility management with easier information exchange (Eastman et al., 2008; Hardin, 2015).

This system gives the ability to model changes in the structure of the building, re-design building with new engineering equipment, bringing its performance up to date requirements, monitor the current status of the building and take timely action for the restoration, competently operate existing facilities' Both technologically and economically, BIM is an additional model for a project's engineering information database, storing all the architectural designs with geometric information and the corresponding technical information for all the works (Ding et al., 2012).

BIM construction standardisation not only contains the geometry of walls, columns, beams, doors, windows, and other building components, but also contains specific attributes for each object, such as material type, material properties, and vendor.

Updating the as-built schedule during the construction phase is generally recognised as the most critical strategy for successful Schedule management (Tserng et al., 2014).

It is required to exchange and deliver intelligent 3D models through all project stages. All plan files and 3D models should comply with the project elevation and coordination system. For BIM use in project delivery, there should be logical object structure and classification system (standards and regulations). For project control in all stages, it is needed to control not only 3D models but also documents, construction processes, etc. Therefore, it is important to manage late changes in a project, provide accurate information for construction, work with many different stakeholders, and create high-quality records for long-term maintenance (Fig. 7).

Tab. 3. BIM design programs used in construction

		Top 10 software of Construction Management by Construction planning criteria				
		ePROMIS Construction ERP	Paskr Project Management Suite	Snappii Mobile Apps	Tenderfield	MySmart-Plans
		SimpleBuild	GamePlan	4PS Construct	Builder-Console	BuilderEdge
Construction planning criteria	Bid management	+	+	+	+	+
	Contract management	+	+	+	+	+
	Job scheduling	+	+	+	+	+
	Lead management	+	+	+	+	+
	Permit management	+	+	+	+	+
	Selection sheets	+	+	+	+	+
	Subcontractor management	+	+	+	+	+
	Submittal management	+	+	+	+	+
	Supplier management	+	+	+	+	+
	Task management	+	+	+	+	+
	Timesheets	+	+	+	+	+
	Warranty/service management	+	+	+	+	+

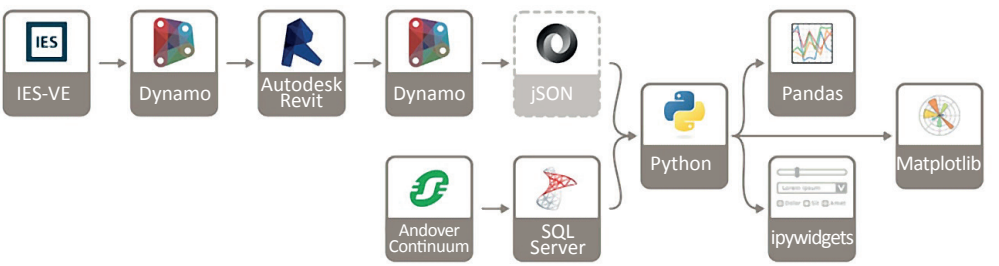


Fig. 6. Building energy calculation path in the BIM environment

Source: (Gerrish et al., 2017).

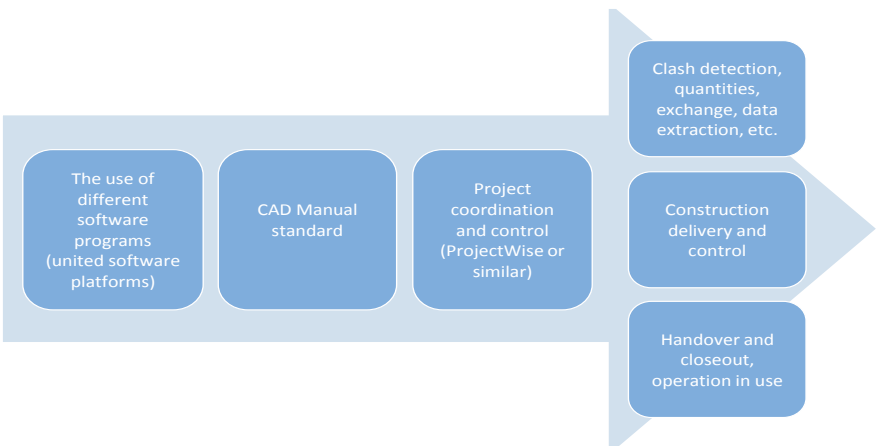


Fig. 7. Project delivery strategy

2. Information interchange between pieces of BIM designs software (handover)

The analysis of the existing pieces of design software and their possibilities demonstrated that the biggest problem is the information distortion and discrepancy after trying to transfer it from one program package to another. This flaw emerged in the BIM packages offered by the same developer because different design software groups require different information sets to perform a task. After the export of the model into a design software format, not all the information was transferred, and after the import of the model, not all the information was recognised. This flaw emerged due to the incompatibility of information structure and content (Vlayton et al., 1999). According to Becerik-Gerber et al. (2012), BIM must be evaluated as an object having a strict structure, corresponding to standard documents and described according to the same criteria. The transfer of the information without defined specific requirements does not ensure the reliability of the transferred information. The best BIM result was achieved using one package for projections, where the created model could be analysed with many different BIM function tools. During this type of projecting, it is not necessary to convert the model into information format, which enables saving the data and ensuring the reliability.

Conclusions

Following the analysis of BIM design software research, it was determined that architectural, construction and MEP programs work best interdependently, and they are analysed the most. These programs work best as they make the least number of mistakes when the model is created in one setting and has many tools. This type of design software data is kept internally and converted into IFC or other information interchange format. The data remains unlost as long as the format remains unchanged; therefore, a fluent information interchange can be performed. The greatest flaws in BIM design emerge from three building process stages:

- the preparation of the building investment project and the existing state analysis,
- the preparation of the building execution technology project,
- the existing standard processing and information collection during the exploitation of the building.

The analysis shows that more research efforts on the BIM design are required to improve information interchange formats to save as much design information as possible and have feedback. As well as in the BIM design, software packages must be improved by supplementing them with deficient tools or program codes.

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