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DIGITIZATION OF CONSTRUCTION AND INFRASTRUCTURE INVESTMENT PROCESSES

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Апстракт

Дигитализацијата е движечка сила зад 4-тата индустриска револуција во секторот градежништво, а позната е уште и како индустрија 4.0 или Градежништво 4.0. Прво, размената на дигитлани податоци меѓу заинтересираните страни во градежништвото ја охрабрува интеграцијата на вертикални и хоризонтални инвестициски процеси и второ, ја поттикнува дејноста градежништво да стане поефикасна, доверлива и транспарентна. Градежните компании и јавните организации интензивно ја внесуваат дигитализацијата во процесите на градба во секојдневните деловни активности, особено при работењето со клиенти/партнери, доставувачи и крајни корисници во текот на повеќе години. Докажано е дека дигитализацијата на процесите во градежништвото решавачки ги засилува и подобрува постојните услуги, но, што е повеќе важно, ја внесува можноста за сосем нови услуги. Нашата цел е да покажеме дека дигитализацијата ги насочува инвестициските процеси, воспоставува подобра култура на соработка меѓу заинтересираните страни и овозможува ефикасно раководење во градежништвото.

Клучни зборови

Градежништво 4.0, планирање на ресурсите на градежните потфати, ЦЕРП, моделирање на информациите за градењето, БИМ, управување со градежни проекти, инженеринг на трошоци, проценка на проекти, контрола на проекти.

Abstract

Digitization has been the driving force behind the 4th Industrial Revolution in the construction sector, also known as Industry 4.0 or Construction 4.0. Firstly, the exchange of digital data among the construction stakeholders encourages the integration of vertical and horizontal investment processes and secondly, it drives the construction industry to become more efficient, credible and transparent. Construction companies and public organizations have been intensively introducing digitization of construction processes in everyday business operations, especially when addressing customers/partners, suppliers and end-users for many years. It has been proven that digitization of construction processes decidedly increases and improves existing services, but more importantly,

introduces the possibility of brand new services. We aim to prove that digitization streamlines investment processes, establishes a better culture of collaboration among stakeholders and enables effective construction management.

Keywords

Construction 4.0, construction enterprise resource planning, CERP, building information modelling, BIM, construction project management, cost engineering, project estimation, project control.

1. INTRODUCTION

The construction industry, although innovative and professional, has a history of delays and over-budget projects. However, its reputation for being inefficient may be changing due to the introduction of digitization [3].

Digitization of vertical and horizontal processes and integration of business models are the foundations of the 4th Industrial Revolution in the construction sector. Large companies, investors and institutions, both private and public, have been introducing digitization of construction processes for many years. They have been increasingly incorporating it into their business operations and in the customers and suppliers communication management. By digitizing the processes, they have been improving their offerings and introducing new services. Construction calls for numerous project participants' cooperation among investors, designers, contractors, suppliers and others. Its digitization improves project monitoring, increases monitoring efficiency, and responds more quickly to project changes. Business digitization is one of the greatest potentials for further development of the construction sector, as evidenced by large investments in digitization.

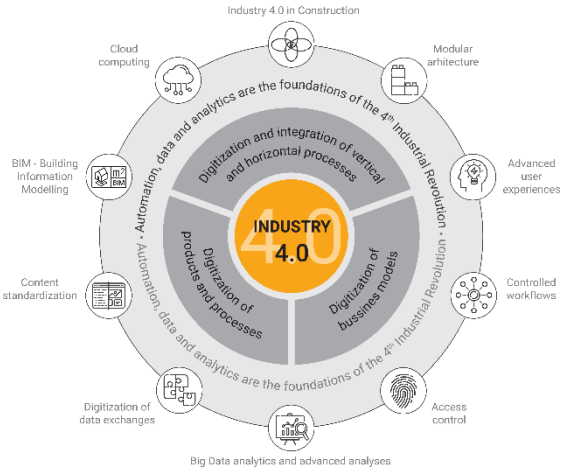

Fig. 1: Construction industry 4.0
Source: www.axis.si

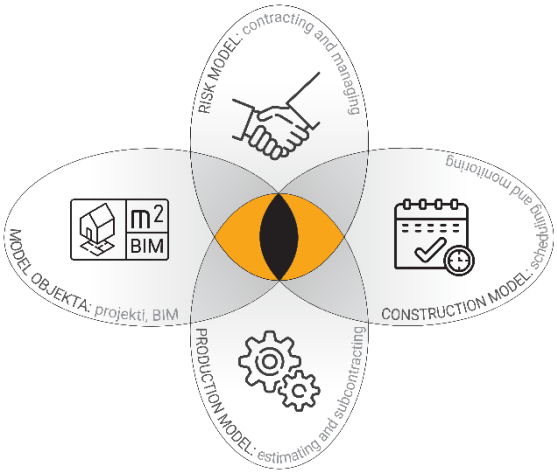

Fig. 2: Multi-model approach
Source: www.axis.si

Construction 4.0 brings major and numerous changes to the thinking and the way the construction sector operates. The greater the change, the greater the opportunity for growth and development. The potential for business optimization, work organization and business integration is vast. It results in easier production adjustment, increases efficiency in resource allocation and reduces energy consumption.

One of the main obstacles to faster digitization of construction sector is certainly a large initial financial investment, which not only relates to the cost of hardware or software but also to changes in the way business is organized, new processes introduced, way of working changed, and additional education and training required. The Future is Now, and decisions on digitization are crucial to achieving increased business results and successful project realization.

2. APPROACH THROUGH PARTICIPANTS' NEEDS

Implementation of infrastructure investments is a complex process involving a large number of stakeholders and a comprehensive interaction among them. Cooperation and communication are crucial for the successful realization of any construction project. Many factors that affect

their cooperation need to be properly organized and well managed. Each stakeholder pursues its own goal in the project and, at the same time a common one, namely the completion of the project within the estimated costs, time and quality. Although there are many stakeholders involved in the construction process, this article primarily focuses on the key stakeholders of any investment process, i.e. investor, designer, supervisor and contractor. Their needs for digitization are addressed according to their activities, roles and needs in the project.

Investors are involved throughout the entire investment process and largely depend on all the other participants. An investor can shield its exposure by proposing or prescribing an appropriate method of digital project management in a common information environment. Thus, enabling the stakeholders to participate in the construction processes with simplicity, ease and quality; e.g. digital communication, electronic exchange of information and electronic documents. The investor will manage the project more easily and efficiently. Digitization should also support the communication channels among stakeholders e.g. by setting up “Project portals”. In order to effectively manage the project, especially its costs, it is paramount that proper digitization of the following key project implementation processes is ensured; preparation of bills of quantities, procurement, tendering procedures, electronic project accounting and integrated scheduling. In this way investor will obtain a comprehensive overview and control over the project and its key components; costs, time, risks, communication, documentation and other.

Public institutions acting as investors have an additional responsibility for the implementation of infrastructure projects due to the expected project development transparency and the efficient use of public funds. Unlike private investors, who are usually focused on the implementation of a single project, public investors usually have to manage project portfolios. As the number of projects increases, the number of information and interactions grows, digitization and standardization become indispensable. The digitization of investment projects should be executed parallel to development of technical specifications and standardization of information, processes and communication.

Financial institutions provide financial resources and enable different methods of financing infrastructure projects. Digitization provides safer financing, better financial liquidity planning and reduces the technical risks involved. Their main objective is to develop the most advanced standards in project monitoring, risk management and project reporting through the digitization of investment processes.

Designers create plans using different technologies and digital tools to achieve investor's expectations about the functionality, quality and cost of the project. Digitization of the design process is especially important for the work of the designers themselves. The growing importance of the upcoming BIM technology found the designers well organized and also well equipped. However, the digitization of the bill of quantities (BoQs) preparation, as key cost management mechanism, is still deficient. This problem becomes even more acute in large and comprehensive projects. In this case, digitization plays a vital role by enabling “live” communication and co-ordination of designers, which can have a significant impact on the preparation time and the quality of BoQs.

Contractors have the most demanding task in the construction process and bear the greatest risks since they have to fulfil also all legal and technical requirements. Last but not least, they must follow their own business goals, which they can only achieve by effectively managing materials, human and financial resources, mechanization, suppliers and subcontractors. Digitization helps them perform accurate cost estimations and effective management of resources. The right approach to digitizing the operations of contracting companies is the integration of project (C), business (ERP) and other specialized information systems. Integration of information systems also requires a certain degree of standardization, which consequently results in overall business efficiency.

3. DIGITIZATION OF THE INVESTMENT PROCCESES

The construction digitization is carried out in several project dimensions, such as documentation management, communication, time, costs, etc. In the following chapter, we will primarily focus on the issue of projects cost management. The preparation of BoQs in digital form and in the prescribed digital format can strongly influence the preparation time and the quality of the BoQs. Professionally and technically consistent BoQs ensure bidders to receive precise instructions on what is expected of them. Consequently, their offers will be more realistic and the risk of potential cost deviation in the project implementation stage will be reduced. Digital BoQ preparation has an evident advantage especially in large or complex infrastructure projects, where many designers and quantity surveyors participate in a single BoQ preparation and their seamless communication is crucial.

The tendering phase, which includes bid preparation, is a stressful period for investors and bidders alike. Digitizing and standardizing the exchange of tender documents including financial bids can ensure complete transparency of the tendering process, which is especially important in the case of public projects. Built-in information system functionalities enable bidders to prepare technically correct and quality bids, prevent investors from potential bid manipulation and provide investors with sophisticated analytical tools for bids comparison.

Construction cost estimation is a process of determining the cost of construction on the basis of material, labour and equipment quantities. Preparing the cost part of bids on behalf of contractors is an extremely complex process that requires estimators with excellent knowledge of construction technology, economics and business organization. Therefore, estimators need an appropriate knowledge database and effective information system support for complex data manipulation. Information system functionalities must be carefully thought-out and tailor-made to meet the estimators' needs, enabling them to focus on proper construction technology selection and minimizing the cost of the investment.

In the construction phase digitization must ensure proper supervision of project costs, time and quality. One of the important issues is the integration of planning information tools and cost management systems. Joining the time component of the construction progress with the cost estimation results in a projected “S” curve. With integration of project accounting information system (C) and business information systems (ERP), comparison of projected and actual project costs is ensured and project monitoring using the EVM (Earned Value Method) method is established. EVM represents a powerful analytical tool for effective financial and scheduling monitoring of projects. In doing so, we ensure timely detection of cost or time deviations and effective change management, which typically represent a major source of disagreement and conflict in any project development.

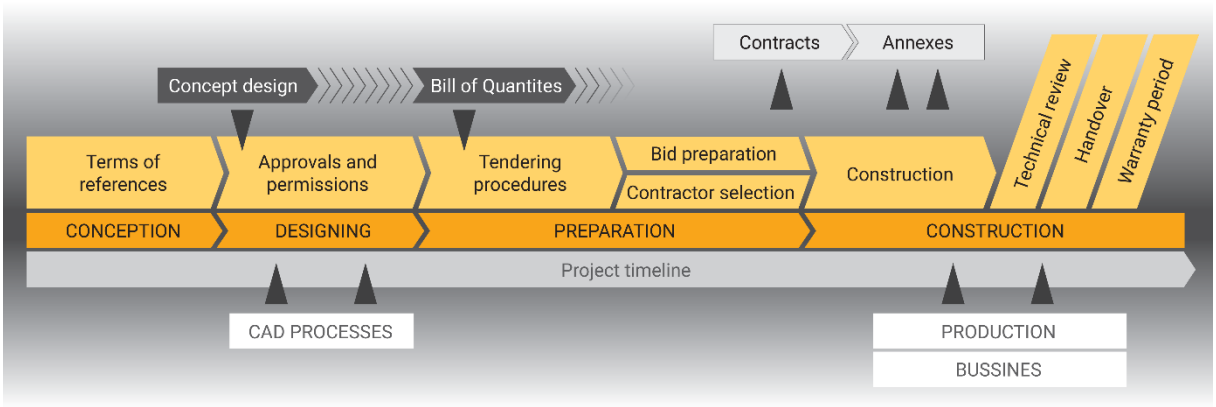

Fig. 3: Sequences of construction processes and procedures
Source: www.axis.si

4. KNOWLEDGE BASE

The knowledge base is an organized electronic database of construction data about materials, products, semi-products, equipment, norms, construction technology standards, prices, archives of completed projects, etc. Due to its systematic, long-term and time-consuming establishment, it is a powerful “fuel” that significantly affects the development of project and cost management in construction.

In the absence of relevant data warehouse, which would meet the general cost engineering requirements, we decided to build our own knowledge base. Many years of construction data collection, organization and research have led us to build it up and offer to our clients. The unique approach allowed us to establish a useful data warehouse tailored to the needs of construction participants. But at the same time we set up our own methodology for collecting, organizing and managing the knowledge base. The methodology can be applied for an independent knowledge base establishment and is adaptable to the specific needs of the different construction business clients.

For the purpose of the transparent organization and efficient management of large amounts of data, we use the international OmniClass classification and our own XBASE classification.

Construction standardization is a fundamental condition for establishing any knowledge base. It is a challenging area for the construction industry as whole and has unprecedented potential for further development. One of the “grey” areas of standardization are standardized work descriptions that we have solved with the parameterization approach. The model allows unlimited number of work description combinations, powerful parameter management, easy language translation, sophisticated analytics and useful pricing history. An identical model is used for norms standardization. Due to its parametric approach, resources and norms can be linked to the BoQs parameters, which enable automated calculation of the BoQ item financial values. The final result is the automation of projects' evaluation and a more accurate estimation of construction investment costs.

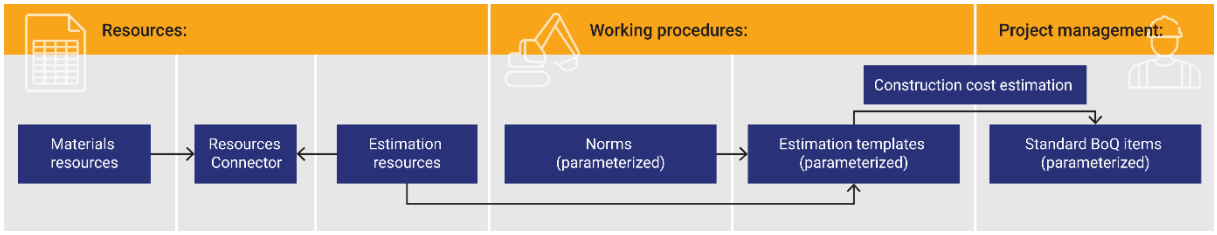

Fig. 4: Knowledge database structure
Source: www.axis.si

5. CONSTRUCTION ENTERPRISE RESOURCE PLANNING

Digitization in the construction sector is taking many directions. The solutions include e.g. simple information tools to support individual works of project participants or comprehensive digital documents management systems. But the only and the key approach of overall digitization is launching of integrated information systems that cover all phases of the investment process and involve all stakeholders. Standard ERP business systems are currently well developed and available on the market for the various complexities of business environments. However, they are deficient for the construction sector because they do not cover all of the construction management requirements. Project managers and other participants need information in a form and manner that allows prompt monitoring and quick response to potential project deviations. Timely availability of information is key to project work and may have a completely different perspective from the project point of view. Due to complexity, construction projects are significantly more subjected to changes than other industries. Therefore, the change management in construction information systems is usually

more comprehensive than in conventional business systems. The integration of project information systems (C) and standard business systems (ERP) is one of the possible and probably the best solution (CERP) that enables the setup of efficient project cost management and fulfil construction business goals.

The result of our internal development in the last 15 years is XPERT. The powerful IT solution for construction project management. XPERT enables efficient project and cost control, estimating, scheduling, resource planning, critical path analysis, communication management, project documents exchange and pre-defined reporting, all in one. It provides easy and reliable investment evaluations, profit/loss analyses, contracting and sub-contracting management, consistency of tendering procedures, performance monitoring and overall projects budgeting. Due to its “live” integration with the MS Project scheduling system, and the capability to integrate with different business systems (Dynamics Navision, SAP, etc.), XPERT is a unique software solution for the construction and infrastructure investments industry. Users can operate without organizational and physical limitations and can participate in projects with fewer communication obstacles. Effective project portfolio management system provides overall control of the investments. It enables everything from efficient resource allocation for individual projects to successful risk-and-return portfolio management at the corporate level.

Fig. 5 Construction Enterprise Resource Planning (CERP)
Source: www.axis.si

Key advantages, benefits and objectives provided by CERP

- Projects transparency, as well as optimizing and increasing construction productivity and profitability.
- Monitoring, controlling and decision-making support at all investment management levels (administration, accounting, trade supervisor, site manager, construction manager, project controller, project management, and executive management).
- Tool for preparation of detailed annual investments plans with effective monitoring of realization and on-time access to key financial and other projects data.
- Work sharing and full teamwork support over project portfolio process evaluation.
- Powerful authorization system, based on user roles and work teams, that provides transparent and secure management of the project contents during all stages.
- Integrated teamwork communication and support with standardized project reporting, analytics, communication and project documentation system.

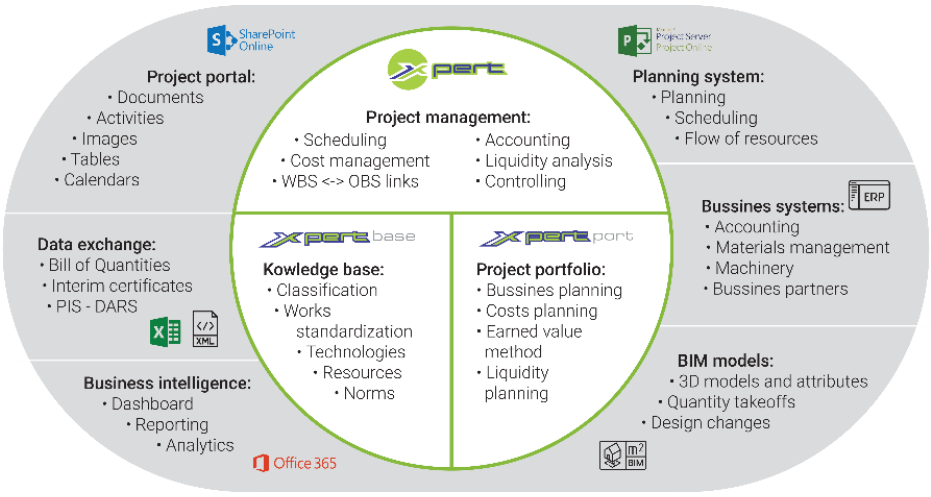

Fig. 6: XPERT - information solution for CERP
Source: www.axis.si

6. CONCLUSION

The construction business has been rapidly developing as a result of growing society infrastructure needs and strong resistance to digitization. Nowadays, construction is facing a daily supply of new materials and products, sophisticated construction technologies, advanced digital design & planning and information systems. Investors are increasing expectations and demands, project deadlines are shortening and financial resources are being limited. Stakeholders in the construction industry, therefore, face dire competitiveness challenges. They are forced to expand their offer, raise the quality of products and services and better coordinate their business. The optimum solution for addressing these challenges is construction digitization. However, we should be honest and note that the digitization of the construction sector is a demanding and time-consuming process because construction is an extremely complex industry due to its project-based orientation.

This article discusses the possibilities of digitizing the construction industry in a horizontal and vertical direction, focusing on managing the costs and time of construction projects and digital communication among stakeholders. Digitization is not only considered from the technical perspective but also emphasizes the importance of standardization of information, documentation, procedures, reporting and other project entities. The current state of standardization in construction is largely limiting the development of the construction industry and constraining the digitization progress.

From the horizontal perspective, all the key stakeholders in the construction process are presented, along with their activities and the benefits of digitization. It is of large importance that the result of digitization goes beyond the actions of individual stakeholders and supports the implementation of projects through optimum cooperation and smooth communication. From the vertical perspective, we considered digitization as a possible optimization and integration of all investment processes. Digitization should facilitate the cooperation of all construction participants which have to realize the projects within the intended objectives.

The introduction of integrated information solutions in construction is one of the most challenging approaches to digitizing the construction business, but also the most effective. It is a complex and time-consuming process that requires a controlled and systematic approach. With good knowledge of business and project processes, organized cooperation of experts, systematic education, use of advanced information technology and finally with the support of management board, it is possible to successfully integrate vertical and horizontal investment processes for successful development of construction projects.

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