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Building information modelling systems: strategic objectives and realities of digital transformation in construction

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The article studies the issue of construction industry digital transformation based on implementation of building information modelling systems. Building information model is to cover all stages of the real estate object's life cycle starting from justification of investments and ending with renovation or demolition of the object. In recent years a thorough regulatory framework has been developed for transition of construction to BIM technologies but construction industry is not yet ready for digitalization. Other participants of processes implemented at all stages of the real estate objects' life cycle are even less ready for it. The article discusses in detail strategic tasks that digitalization of the industry allows solving and advantages that it gives to participants of the real estate objects' life cycle. Some measures are proposed to motivate all participants in the processes of the life cycle of real estate objects to implement building information modeling systems. A platform solution has been proposed that can become a step towards the transition to the next stage of digitalization development — City Information Modeling. Combining a complex of information technologies and a variety of data on one digital platform can become the digital basis of urban management — a system of professional management of urban development in order to best and most effectively use the urban land and property complex in the interests of the population, business and government. The conclusion is made about the need to transfer the "digital revolution" to the evolutionary path of BIM implementation, which should be based on the internal needs of participants in all processes of the life cycle of real estate objects in using this technology for mutually beneficial interaction among themselves.

Keywords: *digital transformation, digitalization of construction, building information model, life cycle of a real estate object*

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INTRODUCTION

Scientific literature and professional publications contain a lot of robust discussions on the prospects of digital transformation of construction industry [1–14]. These discussions reflect not only Russian reality of implementing building information modelling systems but also realities of other developed countries where the process of digitalization of economy, including construction, began much earlier [15–21]. Discussions about digital transformation of the industry continued at the Gaidar Forum on January 13–14, 2022 where this process was literally called "technological revolution".

Despite the fact that over the past three years regulatory framework for implementation of BIM has been under the process of active development, which means that necessary changes have been introduced into the Urban Planning Code of the Russian Federation, government resolutions have been adopted, road maps have been approved, specialized Rules and Regulations have been specified, a classifier of construction information has been introduced[1, 2, 3, 4, 5, 6] [20], the industry appeared not to be ready for the onset dead line defined by the Government Decree No. 331 as of March 5, 2021. The document established obligation to develop and maintain the information model of a real estate object if development of its project documentation happens at the expense of budgetary funds that is for facilities of national and local responsibility.

Major legal acts defining state policy for development of information modelling technology were adopted at the end of 2021. These documents initiated the transition of discussions on digital transformation from theory to more practical aspects. For example, according to the approved strategic plan, information about all residential buildings under construction in Russia will be uploaded to the Housing Construction Unified Information System in the form of information models (information, data, documents) starting from 2023.

1 Rules for the formation and maintenance of an information model of a capital construction object Approved : Decree of the Government of the Russian Federation of September 15, 2020 No. 1431.

2 On establishing the case in which the developer, technical customer, the person providing or preparing the investment feasibility study, and (or) the person responsible for the operation of the capital construction object, ensure the formation and maintenance information model of the capital construction object : Decree of the Government of the Russian Federation of March 5, 2021 No. 331.

3 Action plan ("road map") for the use of information modeling technologies in the design and construction of capital construction projects, as well as for promoting the use of energy-efficient and environmentally friendly materials, including taking into account the need for their production in the Russian Federation : Approved Decree of the Government of the Russian Federation of December 20, 2021 No. 3719-r.

4 Strategic direction in the field of digital transformation of the construction industry, urban and housing and communal services of the Russian Federation until 2030 : Approved Decree of the Government of the Russian Federation of December 27, 2021 No. 3883.

5 Set of rules 301.1325800.2017. Information modeling. Rules for the organization of work by the production and technical departments.

6 Set of rules 333.1325800.2020. Building information modeling. Modeling guidelines for various project life cycle stages.

DATA

The life cycle of a real estate object including "investment justification"–"design"–"construction"–"operation"–"renovation"–"demolition/dismantling" stages is functionally related to activities of many participants of these processes. According to the strategic document there may be more than one hundred contractors and more than 130 procedures involved into implementation of an investment and construction project[4]. Therefore, it is necessary to take into account all the procedures and all the functions performed at each stage of the object's life cycle during the process of development, implementation and utilization of the building information model. There are three groups of economic entities that are potential users of the building information model:

1. Main entities directly responsible for object's life cycle processes: investors, developers/construction owner's technical representatives, design and survey contractors, construction organizations, operating organizations/users of the object.
2. Institutional entities performing various subtasks that establish processes' infrastructure environment and ensure interaction between main participants: expert organizations, appraisers, realtors, insurance companies, marketing consultants, financial and credit institutions.
3. State authorities and local self-government bodies that are not only industry regulators with a whole range of licensing, supervisory and control functions, but often independent market participants at all stages of real estate objects' life cycle.

Undoubtedly, the point of digitalization is to create a single digital platform that will ensure coordination of all information flows and integration of all participants of the real estate object's life cycle. However, neither design organizations primarily impacted by the above-mentioned resolution nor other participants of numerous processes carried out during stages of the real estate object's life cycle are ready for digital transformation. What is more, while architectural and design community has certain understanding of what a digital model of a real estate object should look like, the rest of participants of the real estate objects' life cycle have only a faint idea about it.

According to Federal State Statistics Service (Rosstat)[7] the amount of construction works carried out in the country in 2020 totaled more than 9,498,000 rubles with commissioned 326,703 residential and non-residential buildings all of which are potential objects for digital modelling. There are more than 405,000 construction organizations operating in construction[8] and, according to the Register of National Association of Designers and Surveyors (NOPRIZ), more than 163 thousand organizations carrying out activities in the field of engineering surveys and development of project documentation which makes them potential BIM developers. Currently in Russia there are 85 territorial subjects and 20,303 municipalities[9] which can be potential state and municipal customers and potential immediate users of digital models. Moreover, there are more than 3,500 organizations of various forms of ownership which can act both as BIM customers and as users of these models at the operational stage. Bodies of governmental and non-governmental inspection of design and estimate documentation, state construction supervision and Federal Service for Environmental, Technological, and Nuclear Supervision (Rostechnadzor), the Ministry of Emergency Situations, organizations engaged in scientific and technical support of projects, construction control, financial organizations, management companies, etc. can also be included in the list of potential users of the building information models.

At the same time, digital maturity of all participants in terms of processes of creation and operation of real estate objects differs significantly and this presents the main difficulty in the process of introduction of building information modelling into practice.

STRATEGIC TASKS

It is obvious that the reasons why the Government forces participants of construction market (only in the budget-funded segment so far) to develop and apply information models have solid practical justification. Regulatory documents already allow implementing a number of public services and functions using objects' digital models within the stages of the real estate object's life cycle where state and local self-government bodies carry out initial permitting and registration functions including uploading projects for inspection, transferring models to the information system for urban planning activities (GISOGD), registration of data and obtaining permits for objects' construction and commissioning. Since 2018 there is a Unified Housing Construction Information System (EISJS) which allows getting information about housing construction objects in terms of territories, developers and individual houses.

Digitalization of the industry and organization of objects' information models' accounting allows the state to efficiently solve a number of strategic tasks:

1. Removal of organizations with a low level of competence and professional skills from the list of participants of state order procedures. This will partially solve the problem of low qualification of state contracts for design and construction performers which budget-funded customers regularly face. For example, according to the General Board of State Expert Review (Glavgosexpertiza of Russia)[10] [30] during 9 months of 2021 about 32 % of the total number of project documentation sets contained technical solutions that could lead to risk of emergencies with severe consequences. Moreover, the issues resulting from non-fulfillment of the national projects' budgets in terms of capital construction, as the analysis shows, are largely associated with the fact that electronic auctions are sometimes won by unscrupulous contractors who do not have sufficient production and labor potential.
2. Increasing of level of control over utilization of budget funds for construction/reconstruction of real estate objects. This will prevent intentional or accidental violations during projects' implementation, especially in the situation when funds are managed by federal executive authorities while objects are located throughout the territory of the whole country.
3. Simplification and acceleration of initial permitting procedures and electronic document management system between participants of object's life cycle and elimination of administrative barriers.

7 Regions of Russia Socio-economic indicators. 2021. Rosstat. URL: https://rosstat.gov.ru/folder/210/document/13204

8 Register of all organizations in the field of engineering surveys and preparation of project documentation. NOPRIZ. URL: https://www.nopriz.ru/nreesters/elektronnyy-reestr/

9 The number of municipalities by constituent entities of the Russian Federation as of January 1, 2021. Rosstat. Showcase of statistical data. URL: https://rosstat.gov.ru/storage/mediabank/3CgWEznO/1-adm-2021.xlsx

10 Glavgosexpertiza of Russia. Operational information. URL: https://gge.ru/analytics/operativnaya-informatsiya

4. Improvement of quality of initial analysis of pre-project justification of projects and urban planning policy within territories by means of the unified digital environment (combination of consolidated digital model of the settlement area and digital models of objects).
5. Increase of efficiency level of technical solutions' control:
   - reduction of time and improvement of quality of inspection of project documentation and uploading of models into the GIS data bank called "Unified State Register of Expert Report on Project Documentation of Real Estate Objects" (EGRZ);
   - introduction of a system of remote state construction supervision over activities of construction processes' participants (transition from verification control measures to permanent remote monitoring of construction processes).
6. Control of construction volume and monitoring of competitive environment in construction products' market in order to prevent monopolization.
7. Increase of construction business transparency, reduction of the shadow part of the market and as a result increase in tax collection rate from organizations participating in processes.

ADVANTAGES OF BIM IMPLEMENTATION

Digitalization of a real estate object designing, construction and maintenance processes is primarily the transfer of the system of internal production algorithms of economic entities to a single information platform which will allow optimizing decision-making processes and minimizing production risks and errors. Major developers in Russia (PIK, Aeroplane, Etalon) have already developed and successfully implemented their own BIM standards and automated project management systems (ASUP). Analysis of best practices of digitalization in construction allows highlighting the following advantages for participants of the real estate object's life cycle:

1. *Digital model of the object allows controlling efficiency of funds' spending.* It is obvious that this is one of the major issues for such participants as developers, general contractors or maintenance organizations. However, introduction of BIM will also increase loyalty of banks and investors who will obtain a simple and clear mechanism of monitoring the use of resources. At the same time even the slightest change in the digital model is instantly reflected in the system of technical and economic indicators of the project.
2. Participants of development and utilization of construction products receive a collective digital environment for teamwork, even being geographically distant from each other. All participants are in constant feedback mode which allows *promptly responding to any changes in internal or external conditions.*
3. During implementation of a project a full-fledged digital document flow is maintained for all participants and not only for a separate entity. The electronic document management system allows not only exchanging operational information and making collective decisions but also *automating and making allowances for the completed work's inspection procedure (volume, quality) with the possibility of digital verification of documents by specific officials* — representatives of various entities. For example, the certificate of concealed works' inspection prepared in automated mode immediately on the construction site can be signed by contractor's construction supervision, developer and (if necessary) architectural supervision of the project organization using an electronic digital signature. The signing takes place directly at the time of inspection at the place of works' execution on the construction site. This act is stored in a common data environment and cannot be forged or lost.
4. Possibility of *remote implementation of supervisory activities* on the part of state construction supervision bodies can make the process of implementation of this state function more efficient, minimize corruption risks, reduce need for verification measures by organizing state supervision in the form of permanent/discrete remote monitoring.
5. *Possibility of full-fledged information support of maintenance/renovation processes of the real estate object*, prompt submission and accumulation of data on the object's technical conditions and changes in its technical and economic parameters.

The main goal of digital transformation of the industry is not to create object's information models as a result of project activities, *but in formation of a unified system of interaction of all participants of the real estate object's life cycle using these models.* A system that allows increasing work speed, improving products' quality and providing control of financial and resource flows. *Transparency, specification and constant monitoring will give a cumulative result — all participants in development and utilization of construction products will gain a competitive advantage.*

DISCUSSION

At the same time, according to the authors, there is a number of both objective and subjective reasons that prevent active introduction of information modelling technology into the real estate object's life cycle processes:

Objective reasons are:

1. *High cost of software required for BIM development.* According to the calculations of S. Ovsyannikov, Chairman of the Association Council of "Tomsk Design Association" self-regulatory organization, the transition to BIM technologies for a design organization taking into account purchases of equipment, licensed software, recruitment and training of personnel can reach up to 500,000 rubles per workplace [1]. These are minimum non-recurrent costs. However, it is necessary to take into account mandatory operating costs including one Autodesk workplace in the Architecture, Engineering & Construction Collection package which costs about 145,000 rubles per year and the annual license of one RENGA workplace which costs about 55,000 per year. According to S. Ovsyannikov, only large design organizations teamed up with large construction companies having an assured market can afford such expenses. A similar opinion is expressed by foreign authors [16], noting that medium-sized construction companies do not see the feasibility of investing into BIM since the "cost"–"benefits" ratio is not efficient.
2. *Shortage of qualified personnel.* Few regional design organizations can provide necessary BIM model level of detail, quality of design and project support of construction. The shortage of qualified specialists is experienced by all participants of the life cycle processes. What is more, while for designers who have been working in digital technologies for a long time the transition from 2D–3D design models to 4D (taking into account time factor) and 5D (taking into account cost factor) is difficult but understandable, many developers, construction owner's technical representatives, contractors and even more so state and

municipal authorities simply do not have specialists who are able or ready to work in digital technologies. It should be noted that there are almost no specialists of appropriate qualification level in educational establishments (universities and technical schools that should train personnel for digital construction and real estate management) either.

3. *Lack of demand from BIM users*. Significant costs of creating conditions for working with BIM and lack of qualified specialists, as mentioned above, reduce the demand for digital models from potential users. In addition, not all customers are willing to pay for an increase in design works cost although a 30-percent increase in design cost will only increase the total cost of construction by 2–4 percent.
4. *Lack of domestic software products*. According to the data from a survey conducted by 1C Company among builders and presented at the "Digitalization of construction industry" panel discussion held in February 2022 at the Federation Council of the Russian Federation, 71 % of companies use foreign software and only 19 % use domestic software[11]. As part of implementation of the strategic plan, it is planned to introduce Russian software and hardware. However, this plan will obviously require abundant financial resources and time.

Subjective reasons:

1. *Wariness and lack of trust, rejection of innovations, especially if they are imposed "from above"*. Designers are afraid of the lack of demand for BIM models from customers. Customers are afraid of unwillingness of contractors to work according to corporate and national BIM standards. Even enterprises that have successfully implemented BIM at their construction facilities notice psychological barrier of construction control procedure participants which they meet at construction sites. The situation is somewhat similar to the processes that took place in Russia in 1998–2008 when the industry was shifting from paper design and maintenance of executive documentation to CAD-systems and 3D-visualization. Nevertheless, this factor can be regarded as 'growth disease'. Market mechanisms will undoubtedly be able to cope with the so-called implementation fears, in case there is sufficient attention from statutory regulation and incentive preferences for participants using modern methods of design and construction.
2. *Differences in goal setting of market participants*. Market conditions force all participants to *minimize costs by all available means*. This often results in total cost savings. Designers reduce expenditure on qualified personnel and material and technical resources. Developers save on creating a specialized customer service or attracting construction owner's technical representatives. Developers independently begin to perform a number of functions of the construction owner's technical representative, sometimes even without sufficient qualifications, initiate editing of project documentation and approve it for work. Persons engaged in construction activities (with insufficient construction control by construction owner's technical representative or developer) not only save on qualification of workers and engineers (professional technical and engineering employees) but also replace materials and products provided for by the project at their own volition and allow considerable deviations from design solutions.

CONCLUSION

Analysis of any reforms in relation to business processes especially with utilization of innovative mechanisms indicates that administrative or regulatory documents cannot solve the problem of introduction and effective utilization of new technologies. In this case, measures to stimulate utilization of innovations on mutually beneficial terms for business and state are needed.

The authors propose the following strategic measures for the introduction of information modelling technology by the state:

1. Development of regulatory framework for information modelling in construction including development of a unified set of standards and introduction of classifiers of information, models and elements.
2. Organization and financial support by the state of the system of professional training and advanced training of teachers in universities and technical schools, specialists in construction industry, employees of state and municipal government bodies performing functions of state and municipal customers for implementation of investment projects in the field of development of information technology and BIM models in design, construction and maintenance of real estate.
3. Development of national information modelling platform and its free or subsidized distribution among market participants and educational establishments of the country.
4. Development of a national open source database of elements of information models. The database is to be free of charge for participants and is to be renewed by manufacturers of products/elements/components and other developers. The moderator of the process of the database filling is the Federal Agency for Technical Regulation and Metrology (Rosstandart).
5. Provision of the system of financial support for developers of domestic BIM software and subsidizing/tax incentives for participants of objects' life cycle for its purchasing.
6. Development and implementation of a unified national digital platform-aggregator of ready-made digital models of capital construction projects and a unified digital terrain model that will allow obtaining real-time information on the object and recording changes made to the object in chronological order. This platform should provide the possibility to be integrated with other external systems that allow combining object models and environments in different formats, these shall include:
   - GISOGD (two-dimensional geo-information base surfaces and urban planning data of territories);
   - public cadastral map and Federal Service for State Registration, Cadastre and Cartography (Rosreyestr) data;
   - geological research data;
   - topographic base;
   - industry-based GISs (forests, agricultural industry, investments);
   - engineering facilities (communication networks, resource supply, transport communications, etc.).

The given platform solution can become basis for the next step in digitalization of economy, namely transition to CIM — City Information Modelling — a complex of technologies and various data that combines geo-information systems and digital model detailing in three-dimensional space, collecting information on natural landscape, buildings and infrastructure. City Information Modeling should

11 *Digital "mosaic" will not lead to real digitalization of the industry. Construction Business News Agency. 2022. February. URL: http://ancb.ru/publication/read/12643*

become the digital basis of urban surveying [32] — a professional management system of urban development in order to the best and most effective use of the urban land and property complex in the interests of the population, business and government.

In the authors' opinion, "digital revolution" should be directed into the evolutionary path of BIM implementation which should be based on the internal need of market participants to use such technology to interact with each other. In this case joint efforts of market participants under conditions of comprehensive introduction of information modelling technology will contribute to the increase in efficiency of investment and construction project management and increase in productivity, quality and safety of construction products.

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Технологии информационного моделирования: стратегические задачи и реалии цифровой трансформации в строительстве

Статья посвящена проблеме цифровой трансформации строительной отрасли на основе внедрения building information modelling systems. Building information model должна охватывать все фазы жизненного цикла объекта недвижимости, начиная от обоснования инвестиций и заканчивая реновацией или ликвидацией объекта. За последние годы создана солидная нормативная база для перехода строительства на BIM-технологии, однако строительная отрасль оказалась не вполне готова к цифровизации. Еще менее готовы оказались другие субъекты процессов, реализуемых на всех фазах жизненного цикла объектов недвижимости. В статье подробно рассматриваются стратегические задачи, которые позволяет решать цифровизация отрасли, и преимущества, которые она дает участникам процессов жизненного цикла объектов недвижимости. Выявлены объективные и субъективные факторы, сдерживающие внедрение цифровых технологий. Предложен ряд мер, позволяющих мотивировать всех участников процессов жизненного цикла объектов недвижимости внедрять building information modelling systems. Предложено платформенное решение, которое может стать шагом на пути перехода к следующему этапу развития цифровизации — City Information Modelling. Объединение на одной цифровой платформе комплекса информационных технологий и разнообразных данных может стать цифровой основой урбосервейинга — системы профессионального управления городским развитием в целях наилучшего и наиболее эффективного использования городского земельно-имущественного комплекса в интересах населения, бизнеса и власти. Сделан вывод о необходимости перевода «цифровой революции» на эволюционный путь внедрения BIM, который должен базироваться на внутренней потребности участников всех процессов жизненного цикла объектов недвижимости в использовании данной технологии для взаимовыгодного взаимодействия между собой.

Ключевые слова: *цифровая трансформация, цифровизация в строительстве, технологии информационного моделирования, жизненный цикл объекта недвижимости*

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