MASTER’S THESIS

Development of the Russian construction industry in the context of transition to a digital economy

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ABSTRACT

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The purpose of this thesis is to investigate the digitalization of the Russian construction industry. The thesis includes a review of the existing literature on digital innovations in the construction industry as well as a survey of representatives from Russian construction companies to identify existing problems and opportunities. Then, during the research, proposed to develop a new software for better construction management, including the participation of subcontractors. The proposed project is a digital platform through which all construction project team members and professionals can interact. The program allows to track the progress of work online, ask necessary questions and make adjustments. The study also provides calculations of the proposed program. Calculations are carried out both for the developer and for the customers who will purchase the software. Furthermore, a market research was conducted as a part of this study in order to identify what kinds of digital technologies are already in use and what are the major prospects and challenges for the future development of the industry. Finally, the study presents detailed discussion and conclusions of the obtained results.
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ABBREVIATIONS

BIM  Building Information Modeling
CAD  Computer-aided design
UBS  Unified biometric system
GDP  Gross Domestic Product
3D   Three Dimensional
NPV  Net present value
VR   Virtual reality
MR   Mixed reality
DPP  The discounted payback period
CRM  Customer Relationship Management
PLA  Polylactic acid
IT   Information technology
AI   Artificial intelligence
AEC  Architecture, Engineering and Construction collection
COVID-19   Coronavirus disease 2019
MEP  Mechanical, electrical and plumbing
ROI  Return on Investment
FDM  Fused deposition method
DDP  Discovery-driven planning
2D   Two-Dimensional
ACS  Access control system
SME  Small and medium-sized enterprises
ICT  Information and Communications Technology
1. **Introduction**

1.1 **Background**

Today the requirements for the quality of capital construction objects require the application of modern methods and digitization tools by enterprises to meet regulatory requirements and improve the competitiveness of the enterprise in the construction sector. The current market is characterized by new building materials, new methods of estimating the cost of construction object and new methods of construction and execution of installation work. That is why it is extremely important to find practical tools that allow you to reduce the likelihood of errors and ensure the reliability and safety of construction objects. Modern digital technologies used in the digitization of construction allow the user to solve the above-mentioned problems.

Modernization of business technologies by companies to increase business efficiency is of particular importance. Traditional ways of business organization no longer sufficiently meet the current development trends, so the use of structural transformations that can be implemented through the introduction of modern information technologies will increase economic efficiency, expand sales channels and markets, and improve interaction with customers. As a result, we can talk about the emergence of e-commerce as a way of doing business. The Russian construction sector today has several problems that require the implementation of new digital technologies. The actual deadlines for large-scale investments-construction projects, in practice, exceed the planned deadlines by 20%, the budget-by 80% (Akberdina, 2018).

Today's investment construction market is characterized by a decrease in the productivity of construction work; the economic efficiency of ordered work is mostly unstable and low. The implementation of technological innovations in the construction sector is slow and not very active, and statistical data prove this. The innovative activity (i.e., the percentage of construction companies practicing innovations of any kind) of construction companies in 2021 reached 1.5%. The share of construction companies that practiced technological innovations in 2021 reached 1.1%. This problem is also relevant for digital technologies. The planning of investment construction projects is often incompletely agreed and characterized as formalistic. Agreements with contracting companies often do not include
motivation for innovation and risk-taking, productivity management is not efficient, the organization of supply chains often does not meet the requirements of the project during the entire period of carrying out the project.

The current state of the global economy is characterized by a new transformation associated with the introduction of information and communication digital technologies aimed at collecting, storing, and processing data to reduce all production costs and improve production efficiency. These changes lead to complete revamping of all business processes of market players, representing both government and business. The ongoing digitalization of industrial production is realized within the framework of the transformation of production and product lifecycle management systems through the introduction of breakthrough digital technologies: Virtual Modeling, the Internet of Things, Big Data Processing, Artificial Intelligence, and others, which determine the formation of the ‘digital economy’. The most important benefit of this process is the ability to automatically manage business activities and resources across different sectors of economy, at both macro and micro levels. The digitalization of economy extending to all sectors is changing the nature of business, the ways businesses are managed, and specific projects are implemented.

Being a separate independent branch of economy, construction is intended to create new industrial and nonindustrial facilities, as well as their reconstruction and repair. It accounts for 15% of the gross domestic product of the world economies, and in Russia - 8%. The current construction industry in Russia consists of about 70 thousand economic entities of various forms of ownership with their own features which employ about 10% of the working population. The most important role of the construction industry in the economy of any country is to create conditions for the development of other industries, forming the material basis of any production - fixed assets, and meeting other social needs of society. At the same time, construction has several specific characteristics that distinguish it from other branches of material production: the nature of products; working conditions; peculiarities of machinery, technology, organization of production, management, and logistics.

Global changes in the economy and society driven by digital technologies have also led to digitalization of the construction industry, which can increase the efficiency of production,
take a particular company to a higher level and open new prospects for it in the market. In modern market conditions with fierce competition for a place in the market, the main task of the business entity is to win the preferred market share and maintain superiority over competitors. Improvement of economic efficiency of business is a necessary condition for further development of the enterprise. At the same time, successful economic activity depends not so much on production and financial capabilities of an enterprise, as on effective management of available resources, including implementation of modern innovations, which determines the relevance of the topic of the present study.

1.2 Literature review

In recent years, the digital economy has become one of the central topics of discussion in research literature and the expert community. In the world, more and more attention is paid to the study of digital processes, which are supposed to be able to become drivers of the growth of competitiveness of enterprises, to solve the problem of slowing productivity growth and economic stagnation in developed countries (Sorbe et al. 2019; Bersch et al. 2019), as well as accelerate economic growth in developing countries (Zhang & Chen 2019; Hawash & Lang 2019; UNCTAD 2019).

In this regard, it becomes important to identify the reasons for the introduction of digital technologies in enterprises. In manufacturing industry, the current phase of digital technology development is closely linked to the concept of Industry 4.0. It is the broad and multifaceted process of integrating physical objects, human actors, intelligent machines, and production lines into a single automated information system (Oztemel & Gursev 2020; Agostini & Filippini 2019).

Distinctive features of manufacturing based on the advanced Industry 4.0 technologies are both high efficiency and a deep level of customization of the manufactured product (Ghobakhloo & Fathi 2019; Idrisov et al. 2018). The need for measuring digitalization processes both in manufacturing and other types of economic activity has been increasing over the past decade, causing a high demand for prompt, regular and reliable statistical estimates. However, in international practice, a fully harmonized conceptual framework for the digital economy has not yet been developed. Leading international organizations, making
independent attempts to measure digital phenomena, offer their own definitions and approaches that emphasize various aspects of this multifaceted phenomenon:

- dependence on digital technologies;
- intangible assets;
- massive use of data;
- emergence of new business models;
- social implications etc. (OECD 2015; World Bank 2018).

In current research, it is customary to separate processes such as digitization, digitalization, and digital transformation (Mergel et al. 2019; Vial 2019; Gobble 2018; Osmundsen et al. 2018).

Although the established definitions of these concepts in the literature have not yet been developed, and many authors use them as synonyms, nevertheless, there is a tendency to understand digitization as the transition to digital information storages, while digitalization is associated with changes in socio-technical structures caused by the implementation of digital technologies. At the same time, digital transformation is focused more on managerial aspects of digitalization, being linked to a large-scale process of implementing digital technologies and the corresponding organizational transformations. Digital transformation is the concept now widely popular not only in the scientific literature, but also in the expert and business community (McKinsey 2019; Deloitte 2019).

In the literature there are various approaches to the classification of its factors (see, for example, Machado et al. 2019; Wolf et al. 2018; Osmundsen et al. 2018; Liere-Netheler et al. 2018).

In the theoretical aspect, the existing literature on digital transformation largely inherits the research tradition of «diffusion of innovation» (Rogers 2003; Gokhberg et al. 2016). Indeed, corporate decisions related to digital transformation fit into the wider context of innovative technological development. However, at the level of company management practice, it turns out to be necessary to separate innovation and digital strategies: the concept of digital transformation describes a broad, long, and unified process of internal changes that can have
multiple goals at the same time and result in scale reorganization of the whole business model (Gobble 2018).

Covering all aspects of the enterprise’s activities, digital transformation requires a wide range of participants, as well as following a clear and coherent roadmap, and, as a result, special metrics become necessary for its assessing, which may be irrelevant for the development and implementation of individual innovations (Gobble 2018; Agostini & Filippini 2019). At the same time, we surely agree with the position (DeStefano et al. 2017) that the economic consequences of the introduction of various digital technologies can vary significantly, and therefore the identification of drivers, barriers, and benefits should be carried out separately for digital technologies.

Nevertheless, in our opinion, considering the specifics of the digital transformation process described above, we can talk about both general drivers and barriers to its implementation, studying the introduction of digital technologies in an aggregated form, as well as about the expected benefits and economic consequences of implementing specific digital technologies.

Based on the data array of the results of market surveys of industrial corporate managers available to us, we considered it appropriate to propose our own classification of general factors of digital transformation.

Existing studies reveal the national specifics of digital transformation for several countries. For example, in Germany, the main expected benefits from the introduction of digital technologies in manufacturing are the reduction in the share of production defects, the improvement of labor conditions and labor productivity, and the business drivers are the demand from consumers and the need to integrate within the production chain (Liere-Netheler et al. 2018).

The digital transformation in Hungary, as evidenced by existing research, is mainly at the experimental stage (Feher et al. 2017). It is characterized, firstly, by the large role of IT knowledge and skills not only at the implementation stage, but also at the stage of raising awareness and generating ideas; secondly, the lack of a clear vision and organizational capabilities as one of the main barriers; thirdly, the increased difficulties of enterprises that
have already embarked on the path of digital transformation, resulting from a lack of experience and the necessary skills.

Among the features that are characteristic of Russia in the context of digital transformation, the literature particularly emphasizes the increased level of heterogeneity in the level of development of manufacturing enterprises (Tolkachev & Morkovkin 2019; Nissen et al. 2018).

Authors pay attention to the fact that there is a significant gap between the companies in terms of financial capabilities, the level of competitiveness in international markets, affordable infrastructure, and management practices. As a result, there are prerequisites for a serious gap in the level of digital transformation between the two groups of enterprises (Nissen et al. 2018). The first includes leading companies with a high level of competitiveness and significant development budgets, while the second includes other companies that do not fully see the opportunities of digital development and do not have the necessary budgets for its implementation. They need tried and tested practices, because; unlike the companies from the first group, they cannot work by trial and error when implementing digital technologies. When describing the problems of enterprises from the first group regarding the introduction of digital technologies, the authors mention biases in:

- assessing the outcomes of implementing digital projects (re-evaluation of benefits and underestimation of costs);
- focusing on short-term goals;
- lack of performance metrics;
- and an ad-hoc decision-making manner (Nissen et al. 2018);
- a large dependence of the launched initiatives on state funding in the absence of a unified system for evaluating government support programs (Idrisov et al. 2018).

A common problem for the prospects of Russian manufacturing in the implementation of digital technologies is the lack of specialists with the necessary qualifications (Nissen et al. 2018).
In general, authors give low assessments of the current state of digital transformation in Russian manufacturing (Idrisov et al. 2018; 2018; Tolkachev & Morkovkin 2019). At the same time, the majority indicates the presence of development potential, including due to the low base effect (Korovin 2019; Akberdina 2018).

In recent years, Russia has created a system of state support for the national innovation system, and in particular, sectoral strategies for manufacturing industries (Idrisov et al. 2018).

State support for the introduction of digital technologies in manufacturing enterprises in Russia may become a factor of significant productivity growth, but studies show that this requires a policy aimed at narrowing the gap between a small share of technologically advanced enterprises and others. The relevance of this research topic is the rapid development of electronic data exchange and Internet technologies with the development of international economic relations, which leads to a significant change in the forms of organization.

1.3 The Aims of the thesis

This research aims to find out the implications of the development of the Russian construction industry in the transition to a digital economy. Develop software to manage the implementation of construction projects as a part of improving the management of construction projects in terms of digitalization of the construction industry in Russia.

The following tasks need to be accomplished to accomplish the goal:

- To investigate the current state of digitalization of the Russian construction industry and to determine the main directions of its further development; for this reason, we must consider the existing advantages, risks and problems of Russia's digital economy formation; to analyze existing information technology services and tools used in the construction industry.

- To develop business plan for turning software into product which will allow to manage the implementation of construction projects including with participation of subcontractors. to
analyze existing software offerings for managing the implementation of construction projects.

- To conduct a survey as the base for construction managers to formulate requirements for the functionality of the software to manage the implementation of construction projects.

1.4 Research methods

While writing the thesis, the following groups of research methods were used:

- methods of theoretical analysis: the study of literary sources on the problems of digitalization of the construction industry improving the efficiency of construction project management in Russia;
- surveys with the representatives of construction companies to find out what problems are most often faced by construction companies;
- discounted cash flow method for evaluating the effectiveness of the proposed software project for managing construction projects.

1.5 Structure of the thesis

The structure of the master thesis is the following: an introduction, three chapters, discussions and conclusions, as well as a list of references and appendices. The first chapter is devoted to analyzing the current state of digitalization of Russia's economy, its development trends, technologies and tools in the formation of the digital economy. The second chapter analyses the current state of digitalization of the Russian construction industry; identifies the main directions of its further development and considers the existing information technology services and tools used in the construction industry. The third chapter analyses existing software offers for the management of construction projects involving subcontractors and proposes a new software architecture design in order to improve construction project management in the context of digitalization of the Russian construction industry. The results and discussion contain the main generalizations and conclusions from the study.
2. Market research

2.1 The current state of digitalization of the construction industry in Russia

Construction industry is not in the best shape, which is demonstrated by a drop in investment, frequent bankruptcies of enterprises and difficulties in introducing the latest technologies (Akberdina, 2018). Also, more than 90% of housing is now being built for the money of the population, which indicates a small share of investment in construction by the state and negative consequences for the financial well-being of citizens (Digital Economy 2021).

As for the problems of the latest technologies in construction, for a long time in the Russian Federation they have been trying to force the use of digital technologies forcibly, while this should be interesting for the manufacturers themselves. For example, foreign companies themselves use every new opportunity to use new technologies that give them an increase in labor productivity, an improvement in the quality of construction and the durability of constructed structures (Andreeva, 2018). Consequently, now, require a particularly careful analysis and study of measures aimed at ensuring digital modernization and renewal of the production facilities of Russian construction enterprises, which in the future can become the basis for stimulating the investment attractiveness of this industry.

Now to stimulate digitalization working process is going on three important areas: increasing information literacy of the population, including training highly qualified IT specialists, developing information technologies and infrastructure, and creating transparent legal regulations (Baggio, 2018). It is known that the amount of investment depends on the investment climate in Russia, which is currently not stable and has a number of problems formed due to many influencing factors, such as: low level of innovation, the cyclical nature of the economy, sanctions (Kotov, 2021). All these macroeconomic conditions negatively affect the country's investment climate and, accordingly, the inflow of investment capital, which further negatively affects the development of the digital economy in industries (Listopad, 2021).

As a result, in terms of the level of "digitalization" Russia is among the leading states, and in terms of the "digital economy" Russia lags, including from states with a comparable level of education. This conclusion is clearly demonstrated by the diagram of the shares of the
digital sector in the GDP of different countries, presented in Figure 1.

Fig. 1. The share of the digital sector in the GDP of different countries, % (Digital Economy 2021)

However, progress has been made in 3D modeling and printing. The basic programs, which are developed on a three-dimensional representation of buildings and structures, greatly facilitate decision-making for builders and people. And the state for the development of digitalization of the construction industry is focused on conducting urban planning procedures in an electronic format, in the formation and use of various digital sites and information modeling technology of the ACS (Malyarenko, 2021).

Emphasis is placed on BIM technologies, which are mentioned in the order of the government. The implementation of this order should lead to a reduction in costs and time for the construction of facilities by up to 20%, which undoubtedly attracts investors (Reiter, 2021). Therefore, solving the problem of digitalization in the construction industry is one of the most powerful sources of investment growth. Now, there are already promising directions for the development of digitalization in the construction industry, which are already being implemented:

1. 3D glasses with augmented reality are the most promising and rapidly growing direction. With the help of glasses, you can see future built projects, and it also
becomes possible to completely immerse yourself in the virtual reality of your future home. This all points to good prospects for the development of optimal software.

2. Business management automation is a centralized software package for control of purchases, as well as the consumption of materials. In addition, here you can add tracking of movement, workload and health status of workers using special control bracelets.

3. By carefully monitoring the health and performance of employees, it is possible to increase labor productivity, reduce production costs, and more effectively monitor and standardize the construction process.

4. Demolisher Robots: These robots are used to demolish buildings in places that pose a threat to humans. Thanks to these robots, the percentage of accidents during the demolition of structures is minimized, and the development of machine vision technologies and artificial intelligence systems helps to develop and create new modern construction projects, which is very promising and, undoubtedly, attracts new investment investments from investors (Skorokhodov, 2021).

5. Integrated building sensor systems: with their help, builders can easily monitor the main parameters of buildings and the state of infrastructure networks. The use of this complex system can significantly reduce operating costs, and this program also helps to detect a problem in the building structure in time and allows it to be resolved in a timely manner (Turkova, 2020).

6. IT-geoinformation systems, integrated into BIM technology, are a modern digital product capable of analyzing and storing all the necessary information base of construction objects.

However, despite the entire palette of digital technologies, the data presented by the diagram in Figure 2 indicate that construction does not receive the same amount of investment as mining, real estate transactions, and manufacturing. This undoubtedly shows that the construction industry is less attractive for investments.
Low investment attractiveness is due to the low activity of private construction companies, a decrease in investment investments, as well as the lack of opportunities for private businesses to implement social projects and use modern digital technologies. Thus, one of the most realistic options for overcoming negative factors and ways to increase investment attractiveness in the construction industry, as mentioned earlier, is the development of digitalization, as well as the improvement of public-private partnership mechanisms (Lola, 2021).

To improve public-private partnership in the construction industry, it is necessary (Lola, 2021):

- the formation of consulting project groups that would be responsible for the development and support of projects;
- implementation of comprehensive programs for the selection and support of public-private partnership projects;
- implementation of continuous detailed monitoring at all stages of project implementation;
- to form a legal and economic basis for the development of public-private partnership projects in the construction industry, in which business would be comfortable to fulfill obligations under contracts, to develop a system of effective correct forecasting, adequate

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**Fig. 2.** Data on the structure of investments in fixed assets by type of economic activity in 2020 (Digital Economy 2021).
administrative and legal regulation, and in addition to improve the quality of development, justification, assessment and project implementation.

As for digitalization, as already mentioned, the construction industry in Russia is the most conservative and inertial, but the government is gradually modernizing it and making all the prerequisites for the further development of digital technologies (Kholodov, 2021). Also, digital technologies will help to reduce not only the cost of construction, which was already mentioned earlier, but will also help to increase the energy efficiency of structures, because of which the construction industry will become even more attractive for investments. Thus, it becomes clear that the Russian construction industry currently has several difficulties, but it has good chances of increasing its competitiveness through the use of various digital technologies.

Unfortunately, as mentioned earlier, in Russia the situation with the digitalization of the construction industry is worse than in other countries. Many construction companies in the Russian Federation are just going to switch to new high technologies and have not yet mastered BIM level 1, while other countries are using BIM technologies at level 2 and are going to move to level 3 technologies soon (Gobble, 2018).

Difficulty in the implementation of digital technologies is not unreasonable, since there are factors that hinder the introduction of IT technologies and prevent our state from using digital technologies to the extent that other countries do. The following significant factors are identified (Gobble, 2018):

1) a huge amount of mandatory paper documentation;
2) ignorance of the use of many digital programs, as well as the reluctance and fear of managers to participate in the development of new digital platforms;
3) fear of leakage of corporate information and personal data;
4) past negative experience of using IT systems;
5) sanctions for foreign software.

Thus, in view of a significant set of negative factors, all the difficulties in adapting foreign digital technologies for the Russian construction industry are visible, but development
prospects are also visible, since all the described factors can be solved if possible. Accordingly, there are all the prerequisites for the development of a set of new programs and financial instruments to prevent negative factors and to continue the development of digital technologies that affect the inflow of investments in the construction industry of the Russian Federation. But it is also known that the inflow of investments into the industry for each region and region of the country is different, therefore, this relationship was also analyzed.

The highly developed and most investment-attractive regions for the construction industry in the Russian Federation are those in which highly profitable projects for developers are possible. These regions are characterized by high demand, high average wages and ample opportunities for construction, as well as the possibility of using new technologies. These regions include Moscow and the Moscow region, St. Petersburg and the Leningrad region, the Krasnodar Territory, the Republic of Tatarstan. The regions with the highest rate of residential building commissioning are shown in Figure 3.

![Figure 3: Regions with the highest rate of commissioning of residential buildings, thousand square meters (Digital Economy 2021)](image)

And in regions where high costs remain an important negative parameter, construction activities are extremely unprofitable. For example, in the Kamchatka Territory, where the
cost of construction is one of the highest, construction activities demonstrate negative margins. And in total in Russia for 2021 there are about 5 regions with negative construction margins, which are shown in Figure 4.

![Bar chart showing regions with lowest construction margin](image)

**Fig. 4.** Regions with the lowest construction margin by the end of 2019, RUB/sq. m (Digital Economy 2021)

Positive conditions for doing business, capital advantages, as well as, of course, the level of digitalization of the regions became the key to the first places in this rating. In addition, in many regions there is now an increase in investment potential, which was achieved through the implementation of various reforms, including the creation of a set of measures to reduce barriers at the administrative level, to attract investors by increasing digital technologies.

Thus, the development of digitalization of relations between the authorities and investors - all this directly affects the investment attractiveness of the construction industry, the region and even a particular city among investors - along with other important factors, such as changes in regulatory and legal acts, the introduction of measures to support business, tax incentives and subsidies. Accordingly, by creating electronic services and accelerating the
provision of services, the satisfaction of companies will also increase, and, accordingly, their productivity and their investment attractiveness will increase. If we return to the rating of investment attractiveness of regions in Russia, then Moscow has been occupying the leading position in the rating for many years, thanks to a developed urban planning portal for interaction with developers. In St. Petersburg, which seeks to get into the top three of the rating, its own digital ecosystem is also being developed - a unified system of the construction complex, designed to make the approval procedures in the construction industry clear, controlled and transparent (Kabanov, 2021).

The procedures can be shortened by simplifying business processes, developing data-driven decision-making tools and maximizing the exclusion of a person from the chain of approvals. It became known that together with the Ministry of Telecom and Mass Communications it is planned in the regions to implement a super service "Construction of an individual residential or garden house". The purpose of this super service is to provide services in the field of urban planning in a simplified form. The service is planned to be launched in the near future, it will just reduce the huge amount of paper workflow and minimize the need to visit government agencies. And it is possible that in the future, developers will not need to meet in person with representatives of state authorities and organizations to go through administrative procedures. In fact, a single digital environment will appear in which both business and government will be able to operate (Karacheva, 2021). If we draw a conclusion on the basis of all statistical data, then we can see that such regions as Moscow, the Leningrad region, the Krasnodar Territory, the Republic of Tatarstan occupy leading positions, both in the rating of investment attractiveness and digitalization, and in the rating of regions with the highest rate of construction and commissioning of residential buildings.

Consequently, the construction industry in the Russian Federation develops better and is more investment attractive in those regions where digital technologies are being actively introduced, both in the region itself and in all its production areas. This suggests that it is also necessary to digitize regions as actively as possible and take an example from our capital. Consequently, based on the new statistical data, we again see a positive relationship between the digitalization factor and investment attractiveness, which gives us reason to believe that the hypotheses about the positive impact of digitalization on the investment attractiveness of the construction industry are correct and require further development.
Having analyzed all the data and facts obtained, we see the need to create a set of measures and financial instruments to stimulate the digitalization of the construction industry in the Russian Federation. These include (Digital Economy 2021):

1) granting of subsidies to construction companies by the state to ensure digitalization of construction production processes;

2) the government's lowering of insurance premium rates for construction companies, as it did for the IT industry last year. But only this benefit can be exercised for those construction organizations that use information technology in their activities, as well as develop and implement digital programs in the field of construction processes;

3) implementation by the leaders of digital transformation (RCT) of high-speed online registration of patents, licenses and grants for new digital developments in the construction sector;

4) the development of the unified biometric system (UBS), associated with the simplification of financial payments by the construction companies themselves and their clients. Now biometrics is just beginning its development and is not in demand on the market due to its high cost, but the development of this system at the state level will allow to actively introduce it to the masses, thereby increasing the level of digitalization of construction companies.

Thus, the complex of these events will actively increase the investment attractiveness, which will lead to additional investments in the future.

2.2 Overview of Information technology services and tools in the construction industry

Using Building Information Modeling (BIM), an accurate virtual building model is digitally constructed. This model, called an information model, can be used to plan, design, build and operate a facility, which helps architects, engineers, and designers visualize the needs to identify any potential problems. BIM represents a new paradigm within the AEC that
encourages the joining forces of all stakeholders in a project. The concept of BIM dates to 1975, when Charles M. Eastman, an American professor, published his description of a working prototype in AIA magazine. In the 70s and 80s, similar studies were carried out in Europe, where attempts were made to apply BIM for commercial purposes (Fedorchenko, 2021).

By the 1980s, architects began to perform the first drawings and blueprints on computers using software. Over the past decade, BIM software has evolved into the methodology we know it today. In 2002, Autodesk acquired Revit Technology Corporation. In 2003, Revit became the basis for future development of Autodesk instead of the DWG format, which had been the basis for 20 years. Meanwhile, Bentley Systems and Graphisoft continue to develop their software. Most of the modern educational institutions in the world, in order to keep up with progress, have adapted their curricula to include design with BIM. Building Information Modeling is itself a trend in the AEC field. However, in it one can distinguish several smaller tendencies influencing its development. Here are some of the main trends in BIM that will shape the development of this method in the near future and which should be paid special attention to (Alaloul, 2021).

**3D-printing.** In the coming years, 3D printing will become an essential part of the BIM method. Today 3D printing is one of the best ways to turn a digital model into something real. Combined with BIM, it is possible to create accurate scale models using a 3D printer. However, researchers do not stop at making three-dimensional models. Around the world, there are active attempts to erect finished buildings using 3D printers. Researchers from California succeeded in printing and building a home in just 24 hours using this technology. In China, such experiments made it possible to erect ten buildings in one working day. The building material used as filler for the 3D printing cartridge consisted of recycled industrial waste and cement. Similar tests are being carried out in Europe. Benefits associated with 3D printing include reduced waste of materials, construction time and labor costs, and simplified logistics. The method also provides the broadest opportunities for the creative thought of architects and designers, since 3D printing allows you to easily reproduce curved shapes that are of any curvature that are difficult to manufacture by hand.

A huge amount of information is collected by the BIM model during the design and
construction of a building. Interpreting and examining data collected from BIM models and past projects helps to avoid future mistakes and improve the design and construction process. However, this amount of information significantly exceeds what could be processed by a person. AI-assisted BIM is a new trend that uses rich information to speed up the time it takes to process data and make the construction process much more efficient.

BIM software companies have already started using AI to improve the efficiency and potential of their programs. BIM software can now use machine learning to learn from data and discover patterns and, from that, make independent decisions about how to automate and improve the model building process. Huge amounts of data are collected and used by AI to explore the capabilities of every aspect of a construction project and find the best solution much faster than the human mind can. This not only speeds up processes, but also reduces the risk of human error, which can improve safety at sites. It is likely that there will be much more AI-enabled BIM in the industry over the next decade in the future. AI and the collected data can also be used to improve and even create new designs (Barzhanov, 2021).

With most new technologies emerging, it usually takes some time before they are fully accepted and approved by specialists. Over the past years, BIM has undoubtedly proven to be cost effective. The next step towards its widespread dissemination, apparently, will be the legislative equalization in the legal field of digital BIM-models and two-dimensional drawings, created independently of BIM. Both must have equal legal force. It may be several years before the construction industry accepts this position, but ultimately the need for efficiency and the desire to avoid duplication will lead to contract documents being delivered via a single medium (BIM) and traditional 2D documents will become obsolete. The likelihood of this trend provides a list and format of electronic documents that must be submitted to Moskomexpertiza (Korovin, 2021).

The emergence information modeling provided additional opportunities for wider use of ready-made structures and modules, which, in turn, increases labor productivity and overall economic efficiency of any construction project. This is especially true for so-called mechanical, electrical and plumbing (MEP) multiservice modules. BIM helps ensure the assembly of highly communications-dense integrated MEP systems, which in turn allows designers to make the most of the freed-up usable space for other purposes in high-tech
buildings such as hospitals. With the expansion of BIM adoption, a significant increase in the use of prefabricated and modular structures is expected in the coming years. The use of BIM software technology has facilitated the process of coordinating the factory fabrication of MEP assemblies. Installing MEP systems has historically been a very challenging task. Using BIM software as a tool to facilitate coordination, documentation, and fabrication of MEP systems is an effective approach to overcome these challenges. Information Modeling allows you to avoid functional inconsistencies in design and avoid inconsistencies between individual elements. Thus, all conflicts can be detected and eliminated during the design process, and not after manufacture and installation.

**Virtual reality** provides a spatial-visual representation of the design object and is now becoming a highly effective tool for architects. With the help of VR, the customer can see the finished object at the design stage. The information presented will look much more realistic than a computer 3D model. Accordingly, this means that any problems will be noticed and resolved at the planning stage of the project. In addition, the technology will enable service engineers to inspect technological and communication systems in real time and receive data on any maintenance errors. VR can also request instructions for operating the system from the manufacturer and developer. The next element of virtual reality technology that can be useful is real-time motion capture systems. It allows the user to navigate in a virtual environment just like in a real one, and eliminate the need to use a mouse and keyboard to explore buildings and premises. Some systems have even gone so far as to develop full-body suits with multiple sensors attached to them to make the experience of being in them as real as possible. Mixed reality (MR), which combines the real world with virtual images and holograms, can also help spread BIM technology. MR helps the user to get a deeper understanding of the structure of an object, building or its individual elements. One of the key issues that could slow the adoption of BIM in VR is the technology's cost, but its price has dropped significantly recently (Belostotsky, 2017).

The rapid spread of digital technologies in modern realities determines the direction of development of the economy and society, which leads to fundamental changes in people's lives. The digital economy is one of the priority areas for most of the leading economic countries such as the United States, Great Britain, Japan, Germany, etc. The transition to digital technologies helps to strengthen the competitiveness of national economies.
Russia today does not occupy a leading position in the digital economy, however, it has great potential for further growth. At the end of 2017, Russia ranks 45th according to the ICT Development Index (information and communication technologies) (data from the report of the International Telecommunication Union). This index takes into account access to ICT (Fig. 5).

![Graph showing ICT Development Index, E-government Development Index, and Global Cybersecurity Index with Russia ranked 45th](image)

Fig. 5. Indices of the development of the digital economy of Russia, 2020 (Lola, 2021)

According to ICT Development Index, South Korea is on the 1st place, Germany is on the 12th place, for example. Russia is only on the 45th place here (Lola, 2021). Initially, the term "digital technology" meant the processing of a large amount of information. Subsequently, in 1995, the American computer scientist introduced the term "digital economy", which in a broad sense can be interpreted as a system of interrelated economic relations based on the process of digitalization of information using computer technologies (Dobrynin, 2016).

Its implementation is possible only under the following conditions (Lola, 2021):

1. Prepare business and social sectors for digital transformation. (The presence of a proper legislative framework in Russia regarding the digital economy does not guarantee people's trust in innovation).
2. A fairly mature technological production sector should be formed in Russia, which will increase its productivity and scale of activity in the shortest possible time.

3. Increasing demand for digital technologies among the population, because people's interest is a determining factor in the demand for digital technologies from organizations.

Today, digitalization is most active in public administration, the banking sector, and also in trade. Construction remains a conservative and, at the same time, inertial branch of the economy. Consider in more detail the promising areas of development of digital technologies in construction.

The use of 3D printing in the modern world is gaining momentum. On a 3D printer, objects are printed in layers, and synthetic resins, concrete and steel can be used as materials. Such construction allows you to create structures of arbitrary shapes in the form of an integral part, which cannot be done using production technologies. Reduces material consumption. The first experience of "printing" on a 3D printer already exists in Russia. In 2017, such a residential building was created in Stupino. The whole house is printed on a printer, not assembled from separately printed panels. The area of the house is 36.8 m², and the estimated cost, including finishing, is about 600 thousand rubles. Its unusual geometric shape underlines the great potential of 3D printing construction technology. In fig. 6 you can see this printed object. However, today the creation of even low-rise buildings on 3D printers, according to some experts, is unprofitable, and, therefore, the entire buildings will not be built in the coming years (Bersch, 2019).

One of the main world directions is the use of three-dimensional geospatial data - the so-called 3D geodata. They are used in land use planning, urban planning and architectural - construction design and in the development of new innovative business, for example, identify locations for wind farms, solar energy, "smart" agriculture and forestry, of IT - industry. There are some difficulties here: to create a high-precision digital three-dimensional terrain and relief model, information is required, for the provision of which appropriate tolerances are required, since it reflects the terrain. It remains to be hoped that for the further development of the use of 3B - geodata in Russia, the issue of the regime of cartographic and geodetic information will be revised soon.
One can see the planned projects, ensure the effective promotion of this direction. A gradual improvement in visualization techniques and its application from the building exhibition to the sales office is expected. At this stage, you need to pay attention to the development of good software.

The term "smart city" emerged in the late 1990s. Associated with "green technologies", applied mainly only to environmental friendliness. But in the 2000s, the meaning of this term became inherent in IT - technologies:

1. Sensor systems through which data is received from users and other systems of the city.
2. A digital platform that regulates the life support processes of the city's infrastructure.
3. Directly residents of the city and social institutions.

The main principle of a “smart city” is openness. The information is available to all users. Digital technologies there form a single system and meet all the needs for a comfortable life of citizens: from planning and choosing a comfortable route for moving around the city to sorting garbage.

The main point in the creation of such cities is the correct understanding of the characteristics that smart cities must have to make people's lives comfortable and safe. These aspects should
be carefully considered by scientists, architects, and urbanists (Kitrar, 2019).

The construction industry has gained the potential for innovative development with the advent of information modeling technology (BIM). We can say that BIM is the digital twin of a construction site. Here, the technology of design, construction and operation of a building is considered as a life cycle, that is, this model, being a full-fledged analogue, goes through all stages of the life cycle from the very idea of creation to dismantling. According to experts, the introduction of BIM - technologies can reduce costs by 2%, construction time - by 10%, while reducing the number of errors in design documentation by about 10%. Thus, the main advantages of this technology can be highlighted: improving the quality of project documentation; interaction of all participants in a single information environment of the project; a way to control and reduce the main risks: budget, terms, quality, cost, etc.; transparency of the construction market: digitalization of all stages of construction and their availability in a single information system; lowering the percentage of defectiveness of finished buildings when they are put into operation.

Summarizing all the information presented above, we can conclude that digital technologies have rapidly penetrated into all spheres of human life. It is necessary to develop and adopt several dozen bills, which are required for the effective implementation and operation of a system of advanced technologies. You should also revise the current legislative norms and adapt them to the current tasks of digitalization.

Automation of all procedures in the construction industry throughout the entire life cycle of a property is possible thanks to digital technologies. This should reduce the costs and construction time of the facility by about 20%. The ability to use, designed in BIM object followed by its output to 3D - the printer will allow the potential customer to see the building in reality, the creators of the object - to monitor changes in the project. The use of BIM technologies can be compared to a closed system around a construction site, where an information field is created that contains all information about the construction. Moreover, this data can be used by all interested parties (Kupriyanovsky, 2019). In general, Russians are positive about the introduction of digital technologies. About 60% of the respondents would like to live in a “smart home”. And, according to statistics, the most open category of the population to innovative technologies are people with a high level of income. A positive
aspect is also the fact that in 2020 the level of digital literacy among Russians has increased. People use digital devices more actively, use them at work and store personal data.

Technology company Trimble has brought augmented reality to the jobsite with its SiteVision system, which allows operators to check the viability of new designs and changes, as well as check progress and identify problems during the construction phase. Initially, a BIM or CAD model is imported into the Trimble Connect platform. From there, it is simply loaded onto an Android mobile phone, which is then attached to the antenna using a special bracket. Users can view planned jobs - potentially including underground jobs - superimposed on the actual construction site.

Creating a digital twin of a real project before construction starts allows contractors to order all the materials they need years in advance, ensuring planning safety and allowing them to get the best prices on the market. Contractors and project owners have a set amount of time to complete a project and must do so in the most cost-effective and efficient way - augmented reality helps them do that. “Topcon Magnet Live is a digital web platform for viewing and annotating a 3D virtual model. This provides project stakeholders with all the important conflict and coordination data in a single model. It also allows project owners to better anticipate what might go wrong even before construction starts, so they can fix the problem before it happens in real life” (Lola, 2021).

Autodesk customers are also using their VR technology to improve health and safety by immersing workers in virtual scenarios that would be dangerous in the real world. The virtual world also helps to build and design equipment. BIM technologies are also part of the VR space. However, it is very important to accurately construct the designed building, as well as to be sure that, for example, the ordered equipment can be installed in the given room (Dubovik, 2021).

Equipment and machinery manufacturers, as well as rental and rental companies offer similar programs for the selection of cars. Especially when the work is carried out in a confined space. Such applications create the ability to evaluate a project on site.
providing an interactive experience of using specific equipment directly on the site, you can clearly see how it will cope with the task at hand, whether it will go through all the bottlenecks, whether it will touch the power line. In addition, the application can immediately calculate the cost of the work costs.

2.3 Examples of already successfully implemented digital technologies and projects in Russia

The possibilities of using additive manufacturing technologies can be seen not only in the construction of buildings and structures, but also in relation to all the main stages of the construction process, namely, in design, construction, operation, reconstruction. In addition, the need for CAD software and BIM technologies is evident. Digital manufacturing makes the construction process more efficient. That is, the use of 3D printing technologies can be considered as a factor in increasing the sustainability of the construction industry as a whole. Construction itself is considered labor intensive and costly due to the use of ancillary equipment. The use of additive technologies can solve these problems, because, as mentioned earlier, the use of this technology is associated with the absence of the need, for example, in formwork forms. The process of introducing additive manufacturing technologies continues to be an open issue for further discussion, but the outlook appears to be favorable and promising. Consider an example of the combined use of additive manufacturing and BIM technologies in the construction industry. The application of these technologies has already taken place, for this reason they are becoming indispensable components of further development. At the same time, there are still many unexplored problems in 3D printing technology that require more detailed study. An experiment carried out in a construction company in Russia made it possible to obtain a scaled-down sample of a possible building model. The small dimensions of the sample were taken in order to consistently study and reproduce all stages of project preparation.

The experiment used commercially available software. The 3D modeling workspace was used to create a 3D model. The model was created with the format of the drawing units in millimeters, so that it could be suitable for further printing by a 3D printer in accordance with the units of measurement it used. The equipment used was a MakerBot® Replicator® Z18 3D Printer. The technical characteristics of the printer used are shown in table 1.
Table 1. MakerBot® Replicator® Z18 3D Printer Specifications

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Printing technology</td>
<td>FDM (Fused Deposition Modeling)</td>
</tr>
<tr>
<td>Number of printheads</td>
<td>1</td>
</tr>
<tr>
<td>Number of extruders</td>
<td>1</td>
</tr>
<tr>
<td>Print area</td>
<td>305 x 305 x 457 mm</td>
</tr>
<tr>
<td>Layer thickness</td>
<td>100 microns</td>
</tr>
<tr>
<td>Material diameter</td>
<td>1.75 mm</td>
</tr>
<tr>
<td>Nozzle diameter</td>
<td>0.4 mm</td>
</tr>
<tr>
<td>XY Printing Precision</td>
<td>11 μm</td>
</tr>
<tr>
<td>Z printing accuracy</td>
<td>2.5 μm</td>
</tr>
</tbody>
</table>

The FDM (Fused Deposition Modeling) printer melts the thermoplastic polymer filament and builds the model layer by layer.

To analyze the model data, we used the freely available MakerBot Desktop software version 3.10.1, which was downloaded from https://support.makerbot.com/s/article/Download-MakerBot-Desktop. This program was also used to prepare a print order file for a 3D printer in G-code .MAKERBOT format. After the printing was completed, it was decided to join all the printed parts of the model using dichloroethane plastic adhesive. The material used for printing was REC PLA with a filament diameter of 1.75 mm in an opaque black color (RAL 9004).

In the first stage, all elements of the building model were created from various solids using standard 3D primitives, by means of their mutual editing. The 3D model, as described above, was created using a CAD program. After the entire building model was created, it was cut into separate parts for a 3D printer by creating sections. This operation was carried out in
order to reduce the size of the model to speed up processing and printing. The final model consisted of only 4 parts (Fig. 7). Printing information is presented in table 2.

Table 2. Print Information

<table>
<thead>
<tr>
<th>Element</th>
<th>Dimensions (X x Y x Z)</th>
<th>Print time</th>
<th>Plastic volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plinth (no. 1)</td>
<td>125 x 40 x 40 mm</td>
<td>8:20 h</td>
<td>39.4353 cm³</td>
</tr>
<tr>
<td>External walls (no. 2)</td>
<td>130 x 45 x 50 mm</td>
<td>9:10 h</td>
<td>40.2483 cm³</td>
</tr>
<tr>
<td>Cornice (no. 3)</td>
<td>130 x 45 x 12.5 mm</td>
<td>3:53 h</td>
<td>19.1083 cm³</td>
</tr>
<tr>
<td>Roof (no. 4)</td>
<td>120 x 35 x 5 mm</td>
<td>1:51 h</td>
<td>11.2503 cm³</td>
</tr>
</tbody>
</table>

Fig. 7. Numbering of model elements (Digital Economy 2021)

To determine if there were any defects, holes or incorrect orientation of the normal (inversion), a thorough inspection of the 3D model was required before the next step. This issue can be considered in conjunction with the allowable print sizes, in relation to the used 3D printer, wall thickness and features of filigree parts. It was decided to carry out a visual inspection using cutting planes and check the suitability of the 3D model for printing. The characteristics of the print job are shown in table 3.
Table 3. Printing characteristics

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>First layer height</td>
<td>0.20 mm</td>
</tr>
<tr>
<td>Height of subsequent layers</td>
<td>0.08 mm</td>
</tr>
<tr>
<td>Part filling density</td>
<td>twenty%</td>
</tr>
<tr>
<td>Width of perimeter and padding lines</td>
<td>0.3 mm</td>
</tr>
<tr>
<td>Shell thickness</td>
<td>1 mm</td>
</tr>
<tr>
<td>Number of perimeters</td>
<td>3</td>
</tr>
<tr>
<td>Part fill template</td>
<td>Octagons</td>
</tr>
</tbody>
</table>

Once the previous step has been completed, the print trajectory is set for the model (movement of the print head). At this point, the 3D printer is preparing for the actual printing. Before printing begins, tape is attached to the removable build plate, then it is placed on the build platform and the print media is loaded. During the printing process, the model should fit snugly against the base of the build plate and not have any tears or delamination due to poor adhesion to the surface and low adhesion. Next, a file is launched for printing, which was written in the G-code of the MAKERBOT format. Now you can start directly with 3D printing. First, the printer cools the extruder, then moves it to the starting position for printing, after which it is finally heated. Based on 3D printing technology with fused deposition modeling, building model elements are created by extrusion of molten PLA filament and layering of the extruded material. This procedure described above is repeated with each cross-section of the 3D model until the print head has traveled the entire print path according to the job and has finished creating the printed object.

Considerable attention should be paid to getting started with the 3D printing process. During the construction of the first layer, there is a high probability that the surface of the printed element will tear off the build plate. That is why it is necessary to devote considerable time and attention to the process of organizing and controlling 3D printing. After printing is complete, the print head returns with the carriage to its original position and the removable build plate can be removed. Since the use of compatible building materials for additive
technologies has not yet been sufficiently investigated, the development of materials science in this direction should take place together with the development of BIM. The production technology used in the experiment has a number of attractive and practical advantages when applied. At the time of writing this article, the authors have resolved many important issues related to preparing a 3D model for printing. The authors are of the opinion that the resolved issues are of great practical importance and application in future research. In other words, many other researchers may, in turn, encounter them in their work.

The pictures presented show the step-by-step process of creating a 3D model. As mentioned above, when checking the model for its integrity, both a visual inspection from all sides and a check in a slicer program were used. During the visual inspection, technical characteristics of the printer and especially the printing technology should be mentioned. In the slicer program, the elements of the building model were prepared for printing with control of the main parameters of the operation for further construction of the sample.

After the model was successfully printed, it underwent a thorough inspection. The edges and surfaces of the printed building model were assessed as satisfactory. The subsequent processing of the sample was carried out in accordance with the characteristics of the printed model obtained using this 3D printer. First, we cleaned and sanded the contact edges of adjacent elements of the building model. Then all parts of the model were glued with dichloroethane resin adhesive (Fig. 3). For the complete gluing of the surfaces, the setting time of the building elements of the model was taken equal to 30 hours. The final printed model after assembly is a prototype of its 3D model with great detailing accuracy. This indicates a successful experiment and the achievement of the goals and objectives set at the beginning. All the difficulties that arose during the experiment were described in this article and can be considered as a reference material for subsequent experiments related to additive technologies. In other words, the resulting model of the building obtained as a result of the experiment testifies to the achievement of the set goals.
As noted in the introduction, the experiment was carried out to study and describe the processes of additive technologies. Since the experiment carried out can be considered as a real production process on a scaled-down scale, the visual process of creating a building model made it possible to demonstrate and verify the possibilities of additive technologies associated with application in large-scale construction. Traditional methods of sample creation, including molding, are much more labor intensive even in the context of laboratory experimentation. The experiment carried out has confirmed the close relationship between the individual stages of production and the need for integrated control over their implementation.

As a result of the analysis, a sufficient amount of information about printable building materials was not obtained, which requires further study. The authors are of the opinion that in the course of the experiment, the reliability of the printed model of the building relative to the developed 3D model can serve as confirmation of the possibility of introducing additive technologies into the construction industry. This indicates a similar possibility of application in large-scale construction.

Another key factor requiring more detailed study is topological optimization, which plays an important role not only in the creation and development of a 3D model, but also to obtain more efficient product geometry and improve the mechanical characteristics of solids. There are several examples that demonstrate the relationship between the developed 3D model and topological optimization. This indicates that the 3D model obtained as a result of the
manufacturing process using additive technologies can be used for further calculations and in the design of structures.

2.4 Market challenges and growth opportunities of construction industry in Russia

One of the key elements of the socio-economic system of the Russian Federation is the housing and construction complex, the issues of ensuring the competitiveness of which today find a place among the main positions of national strategic planning. The government ranks sixth in the structure of the country's GDP. According to Rosstat data for 2020, enterprises in the construction industry completed work worth more than 9.13 trillion rubles, and made a 5.6% contribution to the country's GDP (Table 4).

Table 4. Dynamics of the main economic indicators by type of activity "Construction" in the Russian Federation for 2015-2020 (Digital Economy 2021)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Gross value added of the</td>
<td>2587.8</td>
<td>4722.3</td>
<td>4899.6</td>
<td>4998.3</td>
<td>5341.0</td>
<td>5564.6</td>
</tr>
<tr>
<td>economy branch &quot;Construction&quot;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RUB bln (at current basic prices)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>as a percentage of the previous year (at constant prices)</td>
<td>102.1</td>
<td>103.8</td>
<td>102.0</td>
<td>106.9</td>
<td>104.2</td>
<td></td>
</tr>
<tr>
<td>share of construction in gross domestic product, percent</td>
<td>6.5</td>
<td>6.3</td>
<td>6.4</td>
<td>6.0</td>
<td>5.7</td>
<td>5.6</td>
</tr>
<tr>
<td>Scope of work performed for the type of activity &quot;Construction&quot;:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RUB bln (at actual prices)</td>
<td>4454.2</td>
<td>7010.4</td>
<td>7213.5</td>
<td>7579.8</td>
<td>8470.6</td>
<td>9132.1</td>
</tr>
</tbody>
</table>
Table 4 shows that there is a steady annual growth in the gross value added of the “Construction” sector of the economy, however, the share of construction in the gross domestic product by the end of the period under review decreased by 0.9%. So, this indicator in 2015 was 6.5%, and in 2020 it was only 5.6%.

The growth in the volume of work performed by the type of economic activity "Construction" during the study period 2015-2020 occurred by 4,677,982 billion rubles, including the main increase by 113.7% (4,516,818 billion rubles) was achieved due to investments of private organizations.

Table 5. The volume of construction work performed by organizations of various forms of ownership, million rubles (Digital Economy 2021)
The volume of investments in fixed assets of organizations in 2020 for the development of construction activities amounted to 341.4 billion rubles, which is 13.3% less than in 2019. Distribution of investments in housing construction in 2020: private - 97.1%, public - 2.2%, others - 0.7% Separately, I would like to draw attention to the actual and very active reforms and trends in housing construction. The implementation of reforms (from July 1, 2019) in the housing sector is associated with legislative changes related to increased requirements for developers and an increase in banking control; in 2019-2020, a new concept of transition from shared construction to project financing was formed and approved. Among the reform steps, the voluntary possibility of switching to escrow accounts was also

<table>
<thead>
<tr>
<th>Ownership</th>
<th>2018</th>
<th>2019</th>
<th>2020</th>
<th>2021</th>
<th>2022</th>
<th>2023</th>
</tr>
</thead>
<tbody>
<tr>
<td>State</td>
<td>154161</td>
<td>157606</td>
<td>154615</td>
<td>132963</td>
<td>126611</td>
<td>130197</td>
</tr>
<tr>
<td>As a percentage</td>
<td>102.2</td>
<td>98.1</td>
<td>86.0</td>
<td>95.2</td>
<td>102.8</td>
<td></td>
</tr>
<tr>
<td>Of the previous</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Year</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Municipal</td>
<td>16880</td>
<td>17197</td>
<td>18528</td>
<td>18580</td>
<td>20526</td>
<td>19583</td>
</tr>
<tr>
<td>As a percentage</td>
<td>103.9</td>
<td>107.7</td>
<td>100.3</td>
<td>110.5</td>
<td>95.4</td>
<td></td>
</tr>
<tr>
<td>Of the previous</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Year</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Private</td>
<td>3973772</td>
<td>6403224</td>
<td>6527451</td>
<td>6882934</td>
<td>7757959</td>
<td>8490590</td>
</tr>
<tr>
<td>As a percentage</td>
<td>101.1</td>
<td>101.9</td>
<td>105.4</td>
<td>112.7</td>
<td>109.4</td>
<td></td>
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<td>Of the previous</td>
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<td>Year</td>
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<tr>
<td>Mixed Russian</td>
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<td>92614</td>
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<td>As a percentage</td>
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<td>117.7</td>
<td>97.6</td>
<td>101.4</td>
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<td>Of the previous</td>
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<td>Year</td>
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<tr>
<td>Others</td>
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<td>447701</td>
<td>468667</td>
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<tr>
<td>Year</td>
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The result of this reform phase is a record number of building permits received by developers in the first half of 2019. But at the same time, developers are more cautious about the launch of new projects due to a decrease in consumer demand. In the third quarter of 2020, the volume of housing commissioned decreased by 16% compared to the third quarter of 2019, in the fourth quarter of 2020 the volume decreased by 53% compared to the fourth quarter of 2019 and the first quarter of 2020.

The slowdown in new housing commissioning in Russia in 2020 is not unexpected; this is generally explained by the coronavirus crisis and general trends in the economy. The most obvious explanation for the slowdown in new housing commissioning is the postponement of the completion dates, while for the most part developers tried not to suspend the construction of the objects themselves. Considering that we are talking about apartments already purchased but not yet received, it can be predicted that in the second half of the year developers may face a slowdown in demand, the expert said.

Note that restrictions on the activities of construction companies associated with a difficult epidemic situation in Russia may lead to a decrease in the pace of construction. At the end of 9 months. In 2020, the first negative consequences of the crisis in 2020 are already visible: the commissioning of real estate decreased by 2.4% compared to the same period in 2020 and amounted to 81 million square meters. m. Commissioning of residential buildings decreased for 9 months. 2020 by 2.9% to 62.7 million sq. m of the total area, and the commissioning of non-residential buildings decreased by 0.5% to 18.6 million square meters. m. million sq. m).

Construction innovations occur every day, although most of the time they are not recognized as such. Innovation improves manufacturing processes, improves the performance of building materials, and results in material and energy savings, making buildings easy to use, comfortable and sustainable. Indirect innovation effects include improved image, increased customer loyalty and the ability to attract new customers.

The innovative position of domestic construction companies is characterized by low activity
(the number of innovative construction companies in Russia is less than a tenth of their total number). For comparison, in European countries, this figure varies from 30 to 70%.

The state, implementing reforms in the construction industry, ensured a change in the ownership structure and the transfer of the construction industry into private ownership - by 99.1%; the beginning of the transfer of these spheres to self-sufficiency, self-financing, self-government and partially self-regulation.

Target indicators for the development of housing construction until 2035: the annual commissioning of housing is 100 million square meters. m from 2024, 120 million sq. m from 2030; input of individual housing construction at the level of 50 million sq. m from 2024, 60-65 million sq. m from 2030; the volume of the housing stock by 2035 - up to 5.2-5.5 billion sq. m; the level of provision of the population with housing by 2035 - 32-35 sq. m for 1 person.

Support for mortgage lending led to an explosive growth in the volume of housing loans issued: “for the period from April to October 2020, preferential mortgage loans were issued in the amount of 670 billion rubles. (230 thousand pieces). In just 9 months. In 2020, about 1,102 thousand mortgage loans were issued in the amount of 2.7 trillion rubles. (+ 37.8% by 9 months of 2020), and the total bank portfolio of mortgage loans for 9 months. 2020 increased by 14.6% to 8.61 trillion rubles. As of November 2020, 90% of issued mortgage loans are preferential mortgages. Taking into account the extension of preferential mortgage lending until July 2021, the total volume of this program may amount to up to 1.85 trillion rubles. (about 600 thousand credits).

During a pandemic, a set of government support measures was developed to stabilize the construction industry. This was especially evident in the housing construction segment, since this segment is the most transparent and easily amenable to government regulation through federal legislation and banking institutions. All key federal infrastructure projects should receive state support and guarantees, and in the segment of state orders, there is a gradual liberalization associated with the expansion of opportunities for providing prepayments under concluded contracts. Other segments of the construction industry (commercial, industrial construction) actually did not receive systemic government support.
As a result of the implementation of measures of state support in the construction sector (a decrease in the volume of housing commissioning, the introduction of escrow accounts, an increase in the commissioning of individual housing construction, the development of a housing mortgage lending system, including individual housing construction), the national project "Housing and the Urban Environment" was adjusted. The draft Strategy highlighted key "construction problems" (growing need for public infrastructure investments, mainly for transport systems; insufficient level of private capital attraction in infrastructure; high dependence of main transport on government programs; underdeveloped engineering support in industrial construction and low efficiency of project management systems ) and the tasks of developing the industry (improving the system of contractual relations using standard international contracts; increasing the share of life cycle contracts; stimulating the development of construction integrators of the full cycle of turnkey industrial projects; ensuring the possibility of multi-stage design for complex industrial facilities; expanding the geography of construction of agricultural facilities).

Special attention should be paid to the processes of digitalization in the construction industry - as the most promising direction that allows us to improve the innovation and investment sphere of the studied industry of the economy. However, there is a big drawback - the import substitution policy implemented in the country orients corporate business to use domestic IT support, and this leads to an extension of the time for the introduction and testing of new BIM software. One of the directions of development of the construction business is “industry science and staffing”. Within the framework of this direction, a target indicator is highlighted in the draft strategy: increasing the efficiency of research and development in the construction industry, forming a system for introducing innovations.

The problems of the development of industrial science and staffing in the construction industry, as well as ways to solve them, are presented in Fig. 9.
At the moment, the demand for housing in new buildings is supported only by subsidizing the mortgage market, and the stability of developers is ensured by subsidizing interest rates on loans within the framework of project financing.

The clearly expressed problems that have not lost their relevance today include: difficulties in providing the construction sector with highly qualified personnel with competence in construction and installation technologies; lack of uniformity in many design and reporting procedures, moreover, this deficiency is accompanied by excessive bureaucracy; a high degree of wear and tear of fixed assets in the construction industry and outdated energy-intensive technologies. Another significant problem hindering the accelerated development of the construction industry is the high cost of IT support.

Summing up, we note that the Russian housing construction business is waiting for further reforms and changes aimed at developing the industry as a whole. Of course, reforming requires significant costs, updating and updating the legal framework and, in general, well-coordinated work of all market participants, however, in modern conditions of sectoral development of the economy, without a certain "breaking" of a number of business processes, it is impossible to obtain effective results and be globally competitive.
3. Implementation of an effective business model for construction companies in Russia

3.1 Analysis of software offers existing on the market for management of construction projects

The following chapter is an analysis of existing platforms for the management of construction projects as well as the development of a business plan for construction companies in Russia, especially for small and medium-sized businesses to effectively manage business processes and interact with employees and customers.

At present, it is more and more often practiced when all construction services are assumed by a General Contractor. The General Contractor supervises and organizes the work of subcontractor companies, thereby relieving the customer of the need to coordinate the work of several firms. The General Contractor is responsible for the whole project. Well-coordinated work of the Customer and contractors allows to implement the most complicated projects in a quality and efficient way. However, cloudless and problem-free relations between the General Construction Contractor and subcontractor (when all are working synchronously and are satisfied with each other) without special control of the General Contractor, are a very rare phenomenon. A competent General Contractor should constantly monitor and plan the work of the subcontractors. Software market offers a number of specialized solutions to solve various problems arising in the course of construction project implementation with subcontractors. Let's consider the most common ones.

1. FINALCAD is a software solution designed to help engineers, architects, builders, and foremen on construction sites take project management to the next level by helping them do things in a more organized way so they spend more time on actual construction rather than on paperwork. Plans and documents can be digitized and made available to users who collaborate on the same project. FINALCAD stores previous activity, so keeping track of events is no longer necessary when it comes to busy, time-consuming projects.

Among the features of this software solution, one can find an effective team-building option
that also plays the role of a social component. Using this feature, customers will be able to communicate on internal social networks; users can share process photos, create news feed posts, monitor performance, share reports and connect with other team members.

2. Zoho Creato was designed with flexibility in mind, given that it can be integrated to work on a wide range of devices. The functions that the software performs are: convenient document management, easy sending and receiving of RFI (Request for Information), task assignment, punch list management, timely purchase order and portfolio placement, and a dashboard. Construction site managers can get an accurate overview of workers and the status of their projects, whether they are completed, open or overdue. Task Management allows to assign tasks, as well as set deadlines, configure priority levels, and send automatic notifications to your employees about tasks that are pending or waiting for completion.

3. Synapcus is a project management software solution that focused on construction companies, such as architectural firms or property developers, and helps their clients effectively manage their goals, time and budgets. It allows users to divide their project into multiple phases, called work packages, emphasizing the importance of separating projects into multiple layers, especially if they are complex, for easier management; create performance specifications, and define budgets or milestones for each project fragment; provides its users with a team building component that considers several details, including qualifications, personnel availability and cost factors in order to identify the right people for the job.

The program can verify the performance the employer wants and provide cost estimates based on real, actual hourly wage rates; all project-related costs will be recorded in work packages; track over budget, productivity levels and overtime hours at both the project and plant level. Users will be able to export their projects to Excel, create complex reports and access everything mentioned above from their smartphones. In addition, Synapcus comes with a Skype interface and activity wall, so it's easy to keep in touch with any events that might happen in their absence.

4. Build7 is a software solution designed to help builders, architects, supervisors and contractors manage their projects in a convenient and efficient environment, bringing together all the useful tools and connecting all the weaknesses.
The program is designed to work on a variety of devices (from Windows computer to a smartphone or tablet), so its flexibility is great. Users can manage their projects in a multitude of ways by simply logging into the tool from the device of their choice. Build7 allows users to bid, schedule new or existing tasks, manage their projects, view detailed charts and graphs relating to their deliverables, easily create invoices easily; access their employee data and perform other management tasks such as assigning tasks to employees or their dismissal.

The dashboard of this software solution allows users to view a summary of their projects, exceeded scheduled hours, total deliveries, number of invoices created, pending, received or overdue, a timecard, a brief weekly statistic on employees (absent employees, birthdays) and a small note, as record keeping is never a bad thing.

5. ConstructionOnline - this software was developed to help project managers better manage their business and organize it the way they want, without all the hassle of manager efficiency. The tool is available on multiple platforms, including mobile, to eliminate the need to carry a laptop to a construction site or connect it to an office computer whenever something needs to be adjusted within a project.

It can help estimate job costs, customize orders, select your clients more honestly, seamlessly integrate accounting operations, manage calendars and schedules, track projects with daily tracking, footnote lists, tasks and reports, and manage teams without much effort. Features include communication tools with messaging, announcements, RFIs, broadcasts, dispatches and call logging, image galleries support, company tools such as reviews, project templates and dashboards, and finally, sales tools that include ClientLink logins and potential clients tracking.

Platform solutions managing all processes in construction organizations, automate manage and financial accounting, planning and control of work execution (programs for construction and repair) are created to focus on managing the construction business as efficiently as possible without worrying about paperwork, team management or invoicing. The systems consist of functional units divided by construction management areas and use both their own built-in CRM units and work in conjunction with separate CRM systems.

6. Service programs of ALTIUS family.
6.1 ALTIUS - Construction Management program is intended specially for construction organization management and allows to fully automate management accounting, financial accounting, all areas of planning and other business processes of construction companies. With the help of ALTIUS - Construction Management program any construction company will be able to control the progress of construction work in real time, perform financial planning, automatically generate calendar and resource plans, automate workflow, receive a number of reports, maximize the level of construction organization, avoid unplanned costs, thereby increasing the profitability of the construction company.

ALTIUS - Construction Management Program functions are: real-time tracking of project implementation, taking into account actual implementation of works with customer and contractor; automatic generation of reports and plans (work planning and task distribution), maintenance of client base; accounting of contracts with customers and contractors and contract management; automatic generation of network schedules of supply materials, equipment, machinery on sites; marketing tools; accounting of costs and income (cash flow management accounting in the context of both one and a group of own companies, mutual settlements with customers, contractors, suppliers, automatic formation of financial plans as a single construction company, and the entire group of companies); automatically calculate the resource requirements (accounting for inventory and materials).

With the program the construction company will be able to monitor the progress of construction works in real time, perform financial planning, automatically create calendar and resource plans, automate workflow, receive a number of reports, maximize the level of construction organization, avoid unplanned costs, thereby increasing the profitability of the construction company.

6.2 ALTIUS - Construction Digitalization Program is designed to fill in the executive documentation, it contains a functional for accounting contracts and the formation of KS-2 acts. The program features: Contracts registration, control of the implementation of work according to the estimate, formation of KS-2, KS-3 acts with the calculation of insurance deductions and offset of advance payment, the program gives more information for mutual settlements and does not duplicate the estimate program (the estimate program shows only the amount of execution in KS-2 acts but does not give information about the amount to demand from the customer after the signing of the act; The program takes information from the contracts specifying the schedule of advance payments, as well as
information about the warranty (insurance) deductions and the terms of their return. The amount of warranty (insurance) deduction of KS-2 act and the amount of advance payment under this act are calculated on the basis of these data when preparing KS-2 acts. As a result, not only the amount of the act is shown but also the exact amount that the contractor can receive from the customer under the KS-2 act) is calculated. The program contains about a hundred general construction and industry forms.

6.3 ALTIUS - Suppliers and Procurement Program solves the tasks of preventing unreasonable selection of suppliers, building an automated procurement process, increasing the level of employee control. The program helps achieve transparency of the accounting, timely selection of suppliers and competent procurement, provide an opportunity to work for procurement specialists within their competence without relying on data from other departments. All information about suppliers, purchases, materials, their route and much more can be taken into account and controlled by any supplier himself without involving information from other sources of the company.

6.4 CRM and Document Management Program allows systematize and optimize the work with clients and documents, it will be an indispensable tool for organization of participation in tenders (it is possible to attach scanned copies of documents, notifications and other important documentary data, i.e. step by step to monitor the stages of preparation for a tender and its implementation. The CRM part enables to plan the activities of the responsible staff and will automatically remind you of the need to carry out certain actions in relation to documents: annulment, obtaining the original, extension of validity, etc. The list of important cases, events and contact persons coordinating a particular document will be displayed on the screen with a detailed description, which will help greatly facilitate the work of employees responsible for tender preparation).

7. Exo is a cloud platform for automation of all stages of construction, which allows to control and analyze the tasks in a convenient form and maintain digital document flow between project participants. All documentation, photo and video materials, financial indicators are in a single tool available for all construction participants: investor, customer, contractor, subcontractor.
The entire range of logistics, accounting and control systems can be integrated due to flexible configuration and integration with other systems.

3.2 Survey of Owners and Directors of Construction Companies on Requirements for the Functionality of Software to Manage the Implementation of Construction Projects

A survey is often considered a simple approach to research. It is, however, easy to perform a survey of low quality rather than one of high quality and real value, as in any other research approach and process. The term 'survey' is used in several ways, but usually refers to the selection from a predetermined population of a relatively large sample of individuals, followed by the collection of a relatively small amount of data from those individuals. Therefore, the investigator uses data from a selection of people to draw certain inferences about the broader population. In a standardized form, data is gathered. Normally, but not necessarily, this is done through a questionnaire or interview. Surveys are intended to provide a snapshot of how things are at a particular time. There is no attempt to control conditions or manipulate variables; surveys do not allocate or vary the treatment received by participants into groups. (Kelley, et al., 2003)

The surveys questions were prepared for small and medium-size companies to identify the current state of digitalization of construction companies in Russia. The main questions focused on managerial problems of the construction companies and the readiness of the companies to apply innovation technologies into their companies.

The questionnaire was prepared for the survey of owners and top managers of construction companies. Employees of construction companies of the Volga Federal District took part in the survey. The survey was sent to directors and managers of 20 construction companies, such companies as LLC (Limited Liability Company) “ARPI”, LLC “ARIDA” Kazan,(Tatarstan), LLC “VESTLINE” city Bugulma (Tatarstan region), LLC “FELIKS” LLC “VALC” Kazan, etc. The response rate was 60%, so 12 companies sent their responses. The responses received are presented below.
Question 1. Your position.

![Pie chart showing responses to the question 'Your position']

Fig. 10. Responses to the question ‘Your position’

Question 2. Your age

![Pie chart showing responses to the question 'Your age']

Fig. 11. Responses to the question ‘Your age’

According to the question whether the respondents think Russia's construction industry requires changes due to the digitalization of the economy, 54.2% answered
positively, while 45.8% got the negative answer.

Concerning the ability to remotely control the progress of a construction project and increase the efficiency of the company, 66.7% of respondents answered positively and 33.3% negatively.

70.8% of companies surveyed use Construction Project Management Software. And 77.3% apply BIM design technology to their construction projects.

Question 7: How do you interact with remote employees?

Fig. 12. Responses to the question ‘How do you interact with remote employees?’

Question 8. How often do you encounter delays in construction projects?

Fig. 13. Responses to the question ‘How often do you encounter delays in construction projects?’
Question 9: What are the most common problems you encounter in construction projects?

Fig. 14. Responses to the question ‘What are the most common problems you encounter in construction projects?’

Question 10: Has the coronavirus pandemic affected construction projects in your company?

Fig. 15. Responses to the question ‘Has the coronavirus pandemic affected construction projects in your company?’
Question 11: Have you introduced new technologies during your forced social distance?

Fig. 16. Responses to the question ‘Have you introduced new technologies during your forced social distance?’

Question 12. Would you like to be able to store all the necessary data on current projects on one platform with the ability to access them online at any time?

Fig. 17. Responses to the question ‘Would you like to be able to store all the necessary data on current projects on one platform with the ability to access them online at any time?’
The results show that many companies don’t use any software when organizing their business processes. But from the other hand many of them stated that their are ready to apply innovative technologies into their business, what once again emphasizes that the proposed software program which we will introduce in our work will be useful for small and medium-sized businesses.

One of the reasons why companies are ready to introduce apply for new technologies is coronavirus pandemic because many companies were forced to suspend their operations for a long period of time, which negatively affected their businesses and the whole construction industry.

Other factors of such claims are constant delays in projects and non-compliance with deadlines. Also, the lack of time, many managers do not have time to be at the facility physically. New technologies allow monitoring the progress of work at a distance, which significantly reduces the time spent. As a conclusion for the survey, we can mention that currently digitalization level is not high enough, but construction companies in Russia are ready to apply innovation technologies in terms of digitalization of the industry.

3.3 Technical capabilities of the software

As a rule, in the construction industry, main construction contractors outsource design work to subcontractors. But in practice, many subcontractors fail in project implementation for a number of reasons, among them: insufficient qualification and experience of managers and workers, time constraints, financial constraints, and so on. The proposed solution is to create software that will allow monitoring the progress of the construction project both remotely (from the office) and on-site (in the field).

Monitoring will be done by recording observations at the construction site and following up using smartphones, tablets and personal computers. All data is stored on a remote server, and data is exchanged over the Internet via encrypted and secure communication channels using HTTPS protocol. Thus, construction project participants can share data in a single secure information space using all the benefits of cloud storage.
Let's list the main advantages of the proposed software:

- a platform for effective interaction of construction participants on work quality issues;
- structuring of notes on objects and works with the ability to save the construction history of the object with photos;
- access to project documentation from a mobile device with the possibility of linking notes to a specific location in the drawing;
- availability of the reference book of typical defects to save time for filling in the description the notes;
- automatic generation of prescriptions and summary reports.

The program allows to:

- to increase the efficiency of construction control engineers;
- to automatically maintain a register of prescriptions and notifications in electronic form;
- to reduce the time for issuing prescriptions and their elimination;
- remotely monitor all stages of construction anywhere in the world if the Internet is available;
- to ensure prompt communication between the customer, general contractor and construction control;
- Department Heads and Directors to receive operational information from the facility under construction;
- the company's management to reasonably discuss disputable situations with the contractor and the customer, having full information about the identified deficiencies and corrected notes;
- to provide systematic receipt of reports that do not require logging into the program;
- to streamline the work of construction control;
- to ensure full and prompt interchangeability of construction control engineers in case of illness, dismissal, transfer to another position, etc.

The program menu contains the following sections: Projects, Favorites, Help, Settings, User. The main sections to work in the program are the Projects section and the Favorites section.
It is possible to assign different access rights to the data stored in the program, so users with restricted rights will not have access to the Settings section. The Project section contains six sections - Structure, Documentation, Comments, Participants, Analytics and Settings. This Structure section is needed to structure comments and documentation by level of structure. In this section the system administrator creates and adds documents to the elements of the project structure. In the Documentation section it is necessary to add necessary documentation for work in the program. These can be codes, orders, drawings, plans, etc. Drawings are the main and obligatory documents to be added, because without them the work with the program at the object is meaningless.

The program allows to open and work with documents in the following formats:

- DWF - 2D only, vector, multi-page.
- PDF - 2D only, multi-page.
- XPS - multi-page.
- JPG, BMP, TIFF, PNG - single page.

In the Settings section it is necessary to specify information on particular structure level: structure element name, work start date, work end date, full name of the object, object address, etc. All information from the Settings section will be automatically applied to all sub-stages of the structure.

Let’s consider the work with comments. Comments recording. Comments can be created in two ways.

1) Creation of comments without reference to the plan. A number of notes on a construction site do not need to be attached to the plan (drawing). For example, the comment of the construction control manager to the engineer on the acceptance of low-quality material. There may be also the following orders: to take a photo of the work log and many other things.

2) Creating of comments on the drawing. This method is convenient for creating comments that can be shown on the plan. For example, a crack in the wall, corrosion of reinforcement, etc. The following types of filters are provided by the program to handle comments:
- time;
- reporting date;
- overdue;
- performer;
- author;
- performer's organization;
- author's organization;
- demands my attention;
- important;
- Reopened (Remarks that have been reclassified as "Implemented" or "Reviewed" but then reclassified as "Open" because they have not been implemented. Used by supervisors to identify problematic observations).
  - with prescription (Comments with prescriptions);
  - without normative and technical documentation (Comments in which the normative and technical documentation is not selected).

Several filters can be set at once. An additional convenience of the proposed software is the ability to integrate with the existing IT systems, including: MS Project, MS Excel, Oracle Primavera, Spyduk, Projekt, Smeta.ru, Grandsmeta, 1C, MS Sharepoint, SAP, Autodesk Vault, ProjectWise, LOTSMAN PLM, TDMS, NormaCS, TechExpert, Consultant+.

The proposed software contains a powerful Analytics section, which allows users to visually track the progress of work with the help of graphs. All graphs show analytics at the moment (day, hour, minute). It is possible to set the time period for the report. Analytical reports are generated only for the past period. The following analytical graphs are provided:

- Authors ranking by the total number of comments. The graph shows the total number of comments as of the selected date. For the comments that are created by the employees.

- Authors ranking by the comments status. The graph shows the number of comments by status on the selected date. For the comments that are created by employees.

- Performers ranking by the total number of comments. The graph shows the total number of comments on the selected date. For the comments that are assigned to employees.
- Performers ranking by the comments status. The graph shows the number of comments by status as of the selected date. For the comments that are assigned to employees.

- Ranking of performers by overdue remarks. The graph shows the number of overdue comments on the selected date that are assigned to employees.

- Rating by responsible organizations. The graph shows the number of open comments on the selected date that are assigned to employees of organizations.

- The average age of open comments. The graph shows the average rate of comments opening in the selected period (how long on average the comment remained in the "open" status).

- Average time to check the comments. The graph shows the average review rate for comments in the selected period (time between "completed" and "inspected" status of the comments).

- Remarks dynamics by status. The graph shows changes in the status of comments by week in the selected period (how many comments were in the "open", "completed", and "checked" statuses in the given period).

- Dynamics of the total number of comments by state. Cumulative graph shows the dynamics of the number of comments in the selected period.

- Category ranking by status of comments. The graph shows the number of comments by status on the selected date for each category.

- Category ranking by the total number of comments. The graph shows the total number of observations on the selected date for each category.

There are also three types of reports available in the program:

1. Summary report.
2. Prescription.
3. Act.

A summary report can be generated for the entire list of comments with filtering. A prescription can be created either for each comment or for a list of comments. Act on elimination of detected violations. When the comment is transferred to the status "completed" or "checked", a user can create an Act of rectification of detected violations.
3.4 Financial planning and calculations

According to the preliminary estimates made by the specialists of Long Cat Ltd. the cost of development of the proposed software will amounts to 700 thousand rubles with the duration of the development of 3 months. Software sales model - by subscription. The cost of the standard tariff is 24,000 rubles per year or 2,000 rubles per month.

The sales are planned to be implemented in three stages. The first stage is a mass electronic mailing to the database of e-mail addresses of managers of construction companies. According to https://export-base.ru/ there are currently 36,867 construction companies in Russia. The commercial offer for the software product will be sent monthly (3,000 emails per month). The cost of sending 3,000 emails per month using the “Unisender” service will be 2,442 rubles per month. It is assumed that the initial conversion from the mailing list will be 10% or 300 companies per month. Conversion at the second stage (after interaction with sales manager) will be 5% or 15 companies, conversion to software buyers at the third stage will be 20% or 3 companies per month.

Thus, at least 3 sales of 24,000 rubles a month are planned. Then the minimum monthly income from software sales will be 72,000 rubles. The required payback period for software development is no more than 12 months. Let us calculate the efficiency of the project for the development of specialized software for working with contractors using the discounted cash flow method. The discount rate is assumed to be 15% (interest rate on a loan for legal entities varies on average from 10 to 20%, we will take the average value). Here are the formulas for calculating the necessary indicators for assessing the investment efficiency of projects.

The amount of Net Present Value (NPV) for the project is calculated according to the formula:

\[ NPV = \sum_{k} \frac{P_k}{(1 + r)^k} - IC , \]  

where: Pk - amount of annual income;  
IC - size of the investment in the project;  
r - discount rate.
In this case, if:

NPV > 0, then the project should be accepted;

NPV < 0, then the project should be rejected;

NPV = 0, then the project is neither profitable nor loss-making.

The Discounted Payback Period (DPP), if income is evenly distributed over the years, is calculated by dividing the one-time discounted costs by the average discounted annual income:

\[
DPP = \frac{\text{discounted investment}}{\text{average annual inflow of the project discounted income}}, \quad (2)
\]

The Profitability Index (PI) can be calculated according to the formula:

\[
PI = 1 + \frac{NPV}{TIC}, \quad (3)
\]

where: TIC - Total Investment Costs of the project.

The criteria for evaluating an investment project according to the profitability index are as follows:

PI > 1. The project deserves attention; the investment is worthwhile.

PI = 1. According to the NPV criterion, there is one hundred percent self-repayment without profit. If modification of the business project does not allow to squeeze higher profitability, it is better to refuse from financing.

PI < 1. Project activity is unprofitable; the project should be abandoned.

Let us carry out the calculations by tabular method (Table 6).

Table 6. Calculation of economic efficiency of software development project for work with contractor by discounted cash flow method (annual discount rate of 15%)
Based on the data in Table 6, we will make the necessary calculations to assess the effectiveness of this investment project.

\[ NPV = -725,588 + 754,433 = 28,845 \text{ rubles} > 0 \]

Calculation of payback period:

\[ PP = \frac{754,433}{68585} = 10.6 \text{ months} \approx 11 \text{ months} < 1 \text{ year} \]

Calculation of profitability index:

\[ ID = \frac{754,433}{725,588} = 1.04 > 1 \]

Thus, we see that the proposed project will pay for itself in 11 months, with excess of

<table>
<thead>
<tr>
<th>Periods of project life (months)</th>
<th>Investments, operating expenses, rubles.</th>
<th>Savings, rub.</th>
<th>Discount coefficient</th>
<th>Discounted costs, rub.</th>
<th>Discounted revenues, rub.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>700,000</td>
<td>0</td>
<td>-</td>
<td>700,000</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>2,442</td>
<td>72,000</td>
<td>1</td>
<td>2,442</td>
<td>72,000</td>
</tr>
<tr>
<td>3</td>
<td>2,442</td>
<td>72,000</td>
<td>0.9902</td>
<td>2,418</td>
<td>71,297</td>
</tr>
<tr>
<td>4</td>
<td>2,442</td>
<td>72,000</td>
<td>0.9806</td>
<td>2,395</td>
<td>70,600</td>
</tr>
<tr>
<td>5</td>
<td>2,442</td>
<td>72,000</td>
<td>0.9710</td>
<td>2,371</td>
<td>69,911</td>
</tr>
<tr>
<td>6</td>
<td>2,442</td>
<td>72,000</td>
<td>0.9615</td>
<td>2,348</td>
<td>69,228</td>
</tr>
<tr>
<td>7</td>
<td>2,442</td>
<td>72,000</td>
<td>0.9521</td>
<td>2,325</td>
<td>68,552</td>
</tr>
<tr>
<td>8</td>
<td>2,442</td>
<td>72,000</td>
<td>0.9428</td>
<td>2,302</td>
<td>67,882</td>
</tr>
<tr>
<td>9</td>
<td>2,442</td>
<td>72,000</td>
<td>0.9336</td>
<td>2,280</td>
<td>67,219</td>
</tr>
<tr>
<td>10</td>
<td>2,442</td>
<td>72,000</td>
<td>0.9245</td>
<td>2,258</td>
<td>66,563</td>
</tr>
<tr>
<td>11</td>
<td>2,442</td>
<td>72,000</td>
<td>0.9155</td>
<td>2,236</td>
<td>65,913</td>
</tr>
<tr>
<td>Total</td>
<td>726,862</td>
<td>792,000</td>
<td></td>
<td>725,588</td>
<td>754,433</td>
</tr>
</tbody>
</table>
discounted revenues over discounted expenses by 28,845 rubles.
The profitability index of the proposed project is greater than unity and is equal to 1.04.
Let us summarize the obtained data into a single table 7.

Table 7. Main economic characteristics of contractor software development project

<table>
<thead>
<tr>
<th>Technical, economic and financial indicators of the project</th>
<th>Units</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discount rate</td>
<td>%</td>
<td>15</td>
</tr>
<tr>
<td>Investment costs of the project</td>
<td>rubles</td>
<td>700,000</td>
</tr>
<tr>
<td>Forecast of revenue from software sales</td>
<td>rubles</td>
<td>792,000</td>
</tr>
<tr>
<td>Project payback period</td>
<td>month</td>
<td>10.6</td>
</tr>
<tr>
<td>Profitability index</td>
<td>coefficient.</td>
<td>1.04</td>
</tr>
<tr>
<td>Net present value of the project, NPV</td>
<td>rubles</td>
<td>28,845</td>
</tr>
</tbody>
</table>

Consequently, based on NPV, PP, and ID, the implementation of the contractor software project is effective.

3.5 Return on investment and potential customer benefit

The main effect from the program implementation is time saving, increased control over the work performed, and overall control both on the part of the customer and the contractors.

According to forecast calculations the speed of elimination of remarks due to our program will increase by at least 2.5 times, respectively, the time of delay in the construction of the facility can be reduced by 2.5 times.

Let's carry out calculation of predicted efficiency of our program by an example of construction of an apartment house with the area of 21,150 sq.m., including the area of a dwelling part of 16,500 sq.m.

The planned construction period is 24 months.

According to our survey data, construction delays due to ineffective contractor
management amount to 20-25% of the planned construction period. Accordingly, the delays may amount to 5 months on average.

The main item of expenditure during the period of delayed construction is the wage fund, as the consumption of materials and the list of works to be performed remains practically unchanged.

An apartment house construction requires a team of 25 specialists, the amount of the average salary with taxes is 78 thousand rubles a month, the amount of payroll expenses of the whole team is 1,950 thousand rubles a month.

The amount of the increase in construction costs in the case of a standard delay will be:

\[ 1950 \times 5 \text{ months} = \text{RUB 9,750 thousand}. \]

Our program will allow to reduce the cost increase by 2.5 times or:

\[ 9,750 : 2.5 = 3,900 \text{ thousand rubles}. \]

The costs of delayed construction before and after the implementation of our program are shown in the graph 18.

![Graph showing cost comparison before and after implementation](image-url)

**Fig. 18. The key customer benefits**
Then the cash savings on the construction of the facility will be: $9,750 - 3,900 = 5,850$ thousand rubles.

The cost of using our program is 24 thousand a year. Then the net economic effect of using the program on the construction of this facility will be as follows:

$$5850 - 24 = 5826$$ thousand rubles

### 4. Discussion and Conclusions

The study showed that the digitalization of construction should be considered as the management of economic activities and resources in construction, including a digitized (digitized, suitable for recording on electronic media) system for the production and sale of construction products, which, in turn, provides for the digitization of external relationships (cooperative chains) and internal business processes in each construction company.

Problems in the implementation of BIM technologies are the following:

1) an interoperability problem that prevents effective communication in a BIM environment. Interoperability refers to the ability of a product or system, the interfaces of which are completely open, to interact and function with other products or systems without any restrictions on access and implementation.

The above-mentioned plan of action is provided for by the national standards are provided for the design, construction, reconstruction, and overhaul, the preparation, adoption of, regulatory and technical documents, and estimates of the number of standards in the construction industry is to be used;

2) the problem of the lack of qualified personnel with the necessary competencies for the effective use of BIM technologies. Appropriate training programs for information modeling technologies have already been introduced in the educational process of specialized universities, so the training of employees with the necessary qualifications will soon meet employers' requests. To solve this problem, it is necessary to strengthen interdisciplinary ties between students - future builders and students - future developers of software interfaces for data exchange;

3) the problem of insufficient awareness of the benefits of BIM technology among
participants in the construction sector. Many construction companies, especially small ones, consider investment in BIM technology to be excessive and absurd, and continue to work with outdated systems. Need to hold seminars, conferences prove their effectiveness technology BIM practical examples with a real plan: improving the quality of project documentation, the accuracy of estimating the cost of construction, increasing cost control, a significant reduction in the number of errors that are simply impossible to detect within the framework of two-dimensional drawings.

In order to clarify the requirements for future software for construction project management involving subcontractors we have conducted a survey of managers and top managers of construction companies, which confirmed the need for the proposed solution. The solution we propose is to create software that allows you to monitor the progress of the construction project both remotely (from the office) and on-site (in the field).

According to the preliminary estimates made the cost of development of the proposed software amounts to 700,000 rubles with the duration of the development of 3 months. Software sales model - by subscription. The cost of the standard tariff is 24,000 rubles per year or 2,000 rubles per month. The required payback period for software development is no more than 12 months. The calculation of economic efficiency of the proposed project by discounted cash flow method showed that the proposed project will be repaid in 11 months, with excess of discounted revenues over discounted expenses by 28,845 rubles. The profitability index of the proposed project is greater than one and is equal to 1.04. Consequently, based on the NPV, DPP and PI indicators, the implementation of the software development project to manage the implementation of construction projects with the participation of contractors is effective. Based on the study, the following conclusions were drawn.

Most of the methods devoted to assessing the investment attractiveness, both for the industry and for enterprises, do not provide for the analysis and comprehensive study of groups of reasons and factors that affect the flow of investment and the very investment attractiveness of the industry.

It was also revealed that the use of digital technologies in construction is an important factor,
since they significantly reduce costs, as well as facilitate work and increase the efficiency of project management, which is undoubtedly important for the industry, since these indicators increase investment attractiveness and thereby increase the flow investment. Accordingly, Russia needs to increase the development of digitalization and introduce a set of financial instruments that will stimulate a high level of technology in the construction industry, thereby narrowing the gap from countries that are successful in digitalization. But there are factors such as bureaucracy, negative experience in the use of technologies, sanctions on foreign software, which slow down the introduction of IT technologies and prevent our state from using digital technologies to the extent that other countries do. There are all the prerequisites for the development and implementation of a set of new programs and financial instruments for the continuation of the development of digital technologies that affect the inflow of investments into the construction industry of the Russian Federation.
References


