

Effectiveness of using visualization technologies in construction

N G Urazova¹, N V Kotelnikov¹, T A Oparina¹ and A A Malanova¹

¹Irkutsk National Research Technical University, Russia, 664074, Irkutsk, Lermontov st., 83

E-mail: nina_urazova@mail.ru

Abstract. This article describes the relevance of using 3D visualization technology for construction projects. Despite the fact that the construction industry is not knowledge-intensive and is rather conservative in the implementation of innovations, these technologies can increase its competitiveness and ensure sustainable development of the country's economy. Advanced technologies allow increasing the company's revenues, reducing the cost of production, increasing the competitiveness and image of the company. They help to maintain current market positions and conquer new market segments. The use of innovations in the construction industry helps to optimize the use of the entire resource potential of the enterprise, increase the efficiency of using its labor, material, financial and information resources, reduce the cost of construction and installation work, accelerate the speed of information exchange and improve marketing activities. Innovations in the construction industry are introduced at all stages of the life cycle of a construction object: at the stage of project investment, design of a construction object, use of resource-saving and advanced construction technologies, use of energy-efficient building materials, application of innovations in marketing, production organization and personnel management. 3D visualization technologies play an important role in the management of construction stages and design of construction objects. However, today, not enough attention is paid to the economic assessment of the effectiveness of using 3D visualization technology for a particular enterprise. In this regard, the degree of elaboration of the topic is insufficient, and the research topic is relevant.

1. Introduction

The most important branch of the country's material production is construction. It plays a significant role in the socio-economic situation of any country, is an important factor in its stability, creates conditions for the progressive development of society and improves the quality of life of the population.

However, now the effective development of the industry is under threat because of the crisis in the economy. In 2019, housing was received with a total area of 80.3 million square meters, which amounted to 104.9% over the corresponding period of the previous year. [1] Such growth is not expected this year. According to [2], at the end of 2020, housing volumes will be at least 15% lower than last year's volumes.

In this regard, the industry needs more than ever the introduction of innovative solutions to improve the reliability and safety of building structures, reduce the cost of construction and increase its competitiveness. A promising work with new building materials is one in which almost a quarter of patents fall on this area [3]. This is also confirmed by changes in the segmentation of the construction materials markets, which is also associated with an increase in the purchasing power of households and a continuous increase in the volume of residential and industrial construction. The ever-growing



need for modern building finishing work requires builders to apply innovative solutions and technologies. [4]. Today, there are several priority areas for the development of the construction industry highlighted below:

- the introduction of advanced technologies in the building materials industry, construction industry, construction and installation works;
- the creation of industrial buildings with the possibility of their further transformation and modernization, as well as unique civil buildings;
- the use of resource and energy saving technologies and much more.

Obviously, innovation activity should be primarily aimed at: a) improving the technical, economic and architectural level of projects of buildings and structures, b) the quality of construction and installation work.

At the same time, we note that the construction industry is one of the most immune to innovation spheres and occupies one of the last places in the rating of innovative-active industries. [5] There are the following reasons:

- There is a long-time cycle for the operation of the erected structures, which makes it difficult to quickly identify problem areas and shortcomings of the introduced innovative technologies;
- There is an increased responsibility of construction organizations for the quality and reliability of structures of any type being built, because there is a direct link between the responsibility of organizations and the safety of life of many people;
- There are certain preferences in the use of building technologies and materials. This is due to the duration of the development of the construction complex and a large accumulated experience. [6]

Despite these reasons, the statement that the construction complex of Russia is absolutely indifferent to the introduction of innovations is incorrect. It now needs to start integrating new technologies to achieve smarter and better planning, better customer service, and lower construction costs. An industry that has more occupational accidents than any other industry has an increased need for more effective safety measures.

The solution to many problems facing the industry can be the active implementation of visualization technologies for construction objects.

2. Materials and Methods

Visualization of objects is a universal tool from the category of 3D graphics, the capabilities of which are already being used in construction. Its essence lies in the creation of a three-dimensional realistic image of a construction object, which so far exists only in the format of design drawings, using computer technologies. [7]

3D visualization technology is an engineering solution that allows the user to enter the technological aspects of construction and renovation work in a "soft" way. 3D visualization technologies can be a tool for minimizing risks in construction, they contain control over all stages of the project life cycle (PLC): from design to operation, and in some cases, to utilization.

Of course, every innovative construction project must be considered in the three most important areas: timeliness, cost and quality. These factors are dependent on each other. They are reflected in any business contracts and ultimately determine the effectiveness of the implementation of innovative construction projects.

In this case, the use of VRConstructor allows you to neutralize the risks of untimely performance of work using the control method. The development of a planned model of the project should be accompanied by a group of elements of a three-dimensional model and a timetable for the execution of work, and it is also necessary to analyze the possible appearance of space-time collisions. Such synchronization will reduce the chances of emerging risks of untimely execution of construction and installation works before they begin. Monitoring the implementation of all stages of the life cycle will reduce systematic construction risks and promptly respond to the occurrence of deviations of the planned values of work performance from the actual ones.

VRConstructor technology can be effectively used both for projects with complex engineering solutions and for standardized objects. This technology allows you to integrate data about an object at various stages of the life cycle in a single complex system. This opens up a huge number of all kinds

of innovative solutions for complementing and upgrading the 3D model of an object. This technology will allow you to work more effectively with clients in the process of approving and creating a project.

This means that the user is immersed in the virtual world of his future real estate and begins to interact with it. He can do finishing work and complete it (with building materials for decoration, furniture, light, etc.), and eventually get an estimate of building materials and work. This solution connects manufacturers with users. After all, manufacturers integrate ready-made technological solutions into the virtual world, which guarantees the quality of the finished results of repair or construction.

The opportunities obtained by the company after the introduction of 3D visualization technology are presented in Table 1.

Table 1. The opportunities of using 3D visualization technology.

Criterion	Benefits of using 3D visualization technology
Work speed	Increase the speed of work at any stage of the life cycle
Cost	Forecast of costs and volume of required resources for construction (repair) Calculation of the most accurate cost of construction (repair)
Risks	The ability to identify and reduce risks at any stage of the project
Control	Implementation of monitoring of construction and installation works
Controllability	Increased transparency of tender procedures

The introduction of such innovative solutions helps to reduce technical risks, reduce decision-making time and reduce the cost and time of construction. At the same time, it becomes possible to approximately know the costs of future logistics and infrastructure required for a building or structure.

Some analogue of VRConstructor technology are BIM technologies. [8] Like VRConstructor, BIM technologies allow you to create a structure design and work with an information model throughout the entire project life cycle. The differences between these technologies are presented in Table 2.

Table 2. Comparison of VRConstructor technology and BIM technologies.

VRConstructor	BIM- технологии
Interaction of the client with a virtual model of the building in VR space	Interaction through special programs on the computer
The need for mid-range computers + VR system	The need for powerful computers
Staff training takes place in a shorter time (240 hours)	Longer and more complex staff training (about 300 hours)
The cost of purchasing equipment and installing the system is less	High cost of equipment and system installation
This technology can be owned by different firms, including small firms	Ability to have only for large firms

Analysis of this table shows that BIM technologies, in comparison with VRConstructor technology, are more expensive and difficult to learn and use.

Let's consider the effectiveness of using VRConstructor visualization technologies in construction on the example of the functioning of the construction portal YOHOR.ru. The Yohor company supplies and sells modern finishing materials for construction, repair and decoration of any premises from residential to industrial. The main tasks of the company are finishing work for objects that are being built and reconstructed, supplying the customer with a complete set of materials, the correct use of modern technologies in construction and finishing, a significant reduction in the time and cost of work. The Yohor platform is an Internet portal that provides a complete database of construction specialists and has an extensive database of special purpose equipment with modern VR space technology.

Competitors are the greatest threat to the company's operations. These are construction hypermarkets and construction firms that provide comprehensive construction and repair services. The main goals of the company are the promoting of the construction portal YOHOR.ru and the attracting of participants and specialists who could register on the portal and receive and fulfill orders. To do this, it is necessary to increase the attractiveness of the portal for clients, fill the portal database with

tempting content and provide additional services to clients in consulting, design advice and the selection of the necessary building materials.

The development of this technology is based on an attempt to visualize the operations in the VR space that make up the project and their connections. This allows you to simulate the project implementation process in time and minimize all risks.

The first step in minimizing risks should be the creation of a 3D model of the project using VRConstructor technology. After that, it is necessary to develop a planning model of the project and synchronize the structural elements of the model with the calendar schedule. Then the actual model of the project is formed, in which the fixed volumes for certain periods of time are entered. Further, the planned and actual models are merged into a complex model for a specific date. The final stage includes data systematization and analysis, visualization and updating of the work schedule. [9]

The introduction of the new VRConstructor technology will help the company move to a new level of work automation. In fact, the transition to VRConstructor technology means a transition to new software and retraining of personnel. Implementation plan VRConstructor plans implementation costs, necessary implementation measures and personnel training. To do this, it is necessary to:

1. develop an implementation plan for this technology, which includes all its stages, and analyze the costs of specialized software and, if possible, reduce them and consider licensing options.
2. analyze the operation of existing technologies to identify all opportunities for increasing efficiency.
3. train employees to work with the new technology.
4. develop a VR Constructor standard for it and fix the rules of work for personnel.

3. Results

The purpose of the study is the possibility of assessing the effectiveness of the implementation of information modeling in the activities of an organization not only as an innovative, but also an investment project, including the study of the impact of this implementation on all economic indicators of an organization's activities: finance, production, labor resources. Moreover, monitoring of changes of these indicators' values should be constant, like any project that is associated with the introduction of new technologies.

The implementation of VRConstructor technology can be fully regarded as an innovative project. However, this project is also an investment one, therefore it is necessary to highlight those features of VRConstructor that can be attributed to investment projects:

- the VRConstructor implementation project must be considered throughout the entire life cycle, and the assessment phase should not be completed when the design using VRConstructor begins to make a profit;
- assessment of the effectiveness of the implementation of VRConstructor should be carried out constantly, in this case VRConstructor is a classic innovative project, the assessment of which is carried out by the organization that implemented it regularly;
- it is necessary to take into account the interests of all participants in the VRConstructor implementation project, while their interests may not coincide;
- the implementation of each project may have different consequences: external and internal effects;
- it is necessary to compare the work of the company with the implementation of the project and "without the project" On this basis, an assessment of the project implementation should be built;
- one of the most difficult comparisons is determining the cash flows for and after the project. The first chapter has already described the discrepancy between the classical assessment of the effectiveness of the introduction of an innovation, which, of course, is VRConstructor;
- in the same regard, it is difficult to determine those cash flows that can be directly attributed to the benefits of the implementation of VRConstructor, because its implementation affects all the company's activities and its efficiency;
- inflation (in this case, not a specific factor, only mandatory);
- discount accounting (mandatory in evaluating investment innovation projects);

- registration of possible risks assumes that the introduction of VRConstructor technologies reduces them, and the accounting of financial results should be made taking into account the likelihood of this reduction.

From an economic point of view, the assessment of the effectiveness of the implementation of innovations looks quite reasonable. The difficult task of assessing the effectiveness of innovative projects is to take into account the different interests of various participants, whose target settings may differ from each other. [10] In the case of the introduction of VR technologies, the interests of the participants are united not only in increasing profits, although this is the main motive, but also in all the advantages of implementation described earlier: reducing the risks of project implementation, eliminating conflicts in the design, reducing the amount of estimate documentation, etc. The potential effects of implementing an innovative VR technology project can be represented as follows.

Table 3. The effect of the introduction of VR technologies.

Kind	The effect of the introduction of VR technologies
Economic	All types of results and costs in the implementation of VR technologies, expressed in value terms
Scientific and technical	Increasing scientific and technical information; Creation of a new scientific and technical product for the design and implementation of the ISP
Financial	The ability of VR technologies, expressed in financial terms, to generate cash flow for the longest possible period of time
Resource	Cost-effective labor and material savings
Social	Meeting the needs of individuals and society, which, as a rule, do not receive a valuation

The efficiency of investments in the project of introducing visualization technology into the work of the YOHOR.ru portal was evaluated according to the standard method. [11]

At the first stage, the main costs for the introduction of the technology were structured and determined, then calculations were made to assess the effectiveness of the costs incurred. During the study, the following results were obtained.

Table 4. Cost-effectiveness of VR technology implementation.

Index	Value
Investments, rub	1 675 000
NPV, rub.	3 813 118
PI	2,27
PP	10 m

The analysis of the table shows that NPV is positive, the return on investment exceeds the threshold value (1). It follows that investments in the implementation of VRConstructor technology can be considered effective.

4. Conclusion

It is obvious that the development of the construction industry, improving the quality of construction services, reducing the cost of construction and improving the customer service system is impossible without the introduction of innovations. Innovative solutions based on VR technologies can be used as a modern visualization tool available for business today. [12] Their use is not only economically justified, but also significantly improves the customer service system, because the quality of services goes to a new level.

As a result of the introduction of this technology into the activities of the construction portal of the Yohor organization, the quality of services has increased significantly, the company's turnover has grown by 47%. Also, the introduction of new technology has resulted in savings in costs for preparation, project approval, budgeting and preparation of a package for sales and marketing by more

than 12%. There is also a tendency to reduce the development time and order fulfillment (10%), which influenced an increase in the number of order fulfillments and an increase the profit.

These calculations show the high economic efficiency of the use of visualization technologies and confirm the need and relevance of the use of innovative solutions in the construction industry.

References

- [1] Rosstat 2019 *Construction in Russia. 2019: Statistical collection* p 119
- [2] Official website of the Federal state statistics service of the Russian Federation Available at: <http://www.gks.ru>
- [3] Segaev I N, Repnikov M S, Smirnova Yu O 2018 Analysis of modern technical and technological solutions in construction *Modern high – tech technologies* pp 357-361
- [4] Bovkun A, Korodyuk I 2019 Analysis of the development of small innovative enterprises in the construction industry *IOP Conf. Ser.: Mater. Sci. Eng* **667**
- [5] Innovations in the construction cluster: barriers and prospects: analytical review Available at: https://raex-a.ru/researches/city/inno_r_db
- [6] Beloglazova M S 2018 Analysis and problems of the construction industry *Young scientist* **4** pp 104-107
- [7] Litvintseva E 2016 The Battle for 3D: if will take root in Russia "printed" house *Building materials, equipment, technologies of XXI century* **9**(10) pp 48-49
- [8] Alsynbaev R H 2017 The Use of BIM technologies in construction *Innovative science* **11** pp 13-15
- [9] Zaretsky A D 2014 *Industrial technologies and innovations: textbook. for University students. educational institutions studying in the direction of 222000.62 "innovation": for bachelors and undergraduates* p 473
- [10] Asaul A N, Gorbunov A A and Zavarin D A 2016 Features of investment planning of innovative investment and construction projects *Construction Economics* **1** pp 32-42
- [11] Vilensky P L, Livshits V N and Smolyak S A 2002 *Evaluating the effectiveness of investment projects. Theory and practice* p 888
- [12] Melnikov D A and Dmitrieva T L 2020 Validation of the load-bearing capacity of the frame assembly of metal structures on the standard 2.440 series using IDEA StatiC *Proceedings of Universities. Investment. Construction. Real estate* **10**(3) pp 406–419
- [13] Skorobogatova Y A, Bovkun A S, Ivanov Yu M and Shilova O S 2020 The role and place of small innovative enterprises in the construction industry in the modern economy of single-industry towns *IOP Conference Series: Materials Science and Engineering* **880**

Reproduced with permission of copyright owner. Further reproduction prohibited without permission.