ISSN 2073-8412

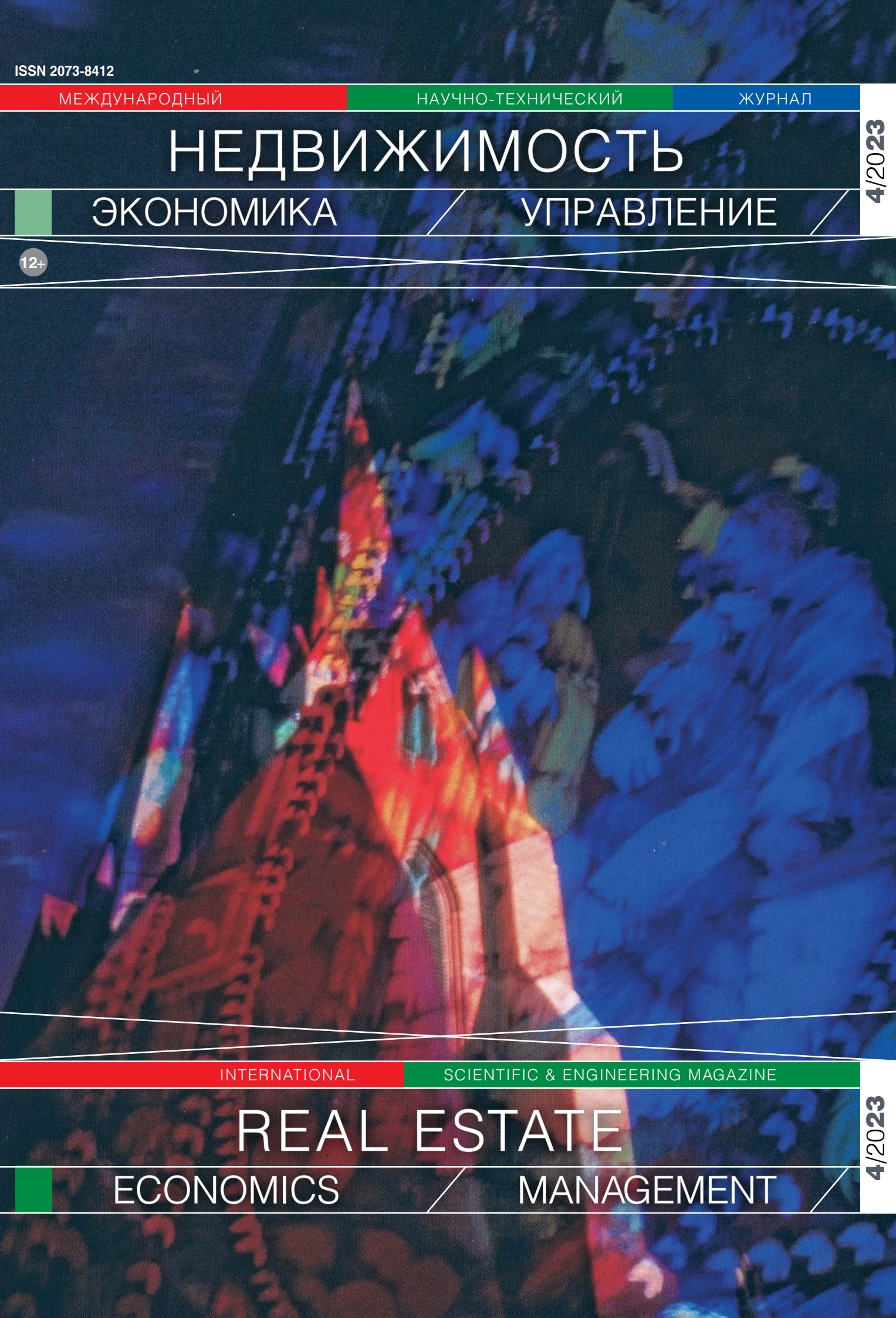
МЕЖДУНАРОДНЫЙ НАУЧНО-ТЕХНИЧЕСКИЙ ЖУРНАЛ

НЕДВИЖИМОСТЬ

ЭКОНОМИКА / УПРАВЛЕНИЕ

4/2023

12+



INTERNATIONAL SCIENTIFIC & ENGINEERING MAGAZINE

REAL ESTATE

ECONOMICS / MANAGEMENT

4/2023

ISSN 2073-8412

НЕДВИЖИМОСТЬ

ЭКОНОМИКА ■ УПРАВЛЕНИЕ

Учредители:

Федеральное государственное бюджетное образовательное учреждение высшего образования «Национальный исследовательский Московский государственный строительный университет» (НИУ МГСУ);
Издательский дом «АСВ»

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2.1.14 Управление жизненным циклом объектов строительства (технические науки)

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Основан в 2001 году. Выходит 4 раза в год.
Подписан в печать 19.12.2023.
Выход в свет 28.12.2023

СВИДЕТЕЛЬСТВО О РЕГИСТРАЦИИ СРЕДСТВА МАССОВОЙ ИНФОРМАЦИИ: ПИ № 77-11025 от 30 октября 2001 г. выдано Министерством Российской Федерации по делам печати, телерадиовещания и средств массовых коммуникаций.
Адрес в сети Интернет: **http://n-eu.iasv.ru/**

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Тел.: +7 (968) 903-00-04; e-mail: info@n-eu.ru

На обложке печатаются работы фотохудожника Валентина Герцмана (Нью-Йорк).



Уважаемые читатели!

Будучи одной из важнейших инфраструктурных отраслей российской экономики, строительство обеспечивает не только ее жизнеспособность и развитие, но и комфортную среду жизни и деятельности.

Жилищное строительство продолжило развиваться бурными темпами. При этом наметился структурный сдвиг в сторону индивидуального жилищного строительства. Словом, в условиях нарастающего санкционного давления и репутационной блокады российской экономики именно строительство стало мощнейшим фактором, обеспечивающим не только устойчивость, но и ускоренное развитие секторов, нуждающихся в импортозамещении, а также определяющих будущие параметры и преимущества российской экономической модели. Ее уязвимость в настоящее время стала следствием копившихся последние десятилетия противоречий и рисков развития.

Строительство, будучи важнейшей фондосоздающей отраслью, обеспечивающей структурно-технологический маневр российской экономики, нуждается в коренной технико-технологической трансформации. Модели инвестиционно-строительной деятельности также требуют обновления.

На фоне санкций в отношении крупнейших банков страны единственным оперативным решением поддержки отрасли в потоке преодоления пределов роста является увеличение бюджетного финансирования. Очевидно, речь идет не обо всех проектах, а только о стратегически ориентированных на обеспечении экономического и технологического суверенитета. В инвестиционно-строительной сфере — это инфраструктурный форсаж, осуществляемый на расширяющейся отечественной технологической базе.

С уважением, главный редактор, **Пётр Грабовый**

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СОДЕРЖАНИЕ

АКЦЕНТЫ НОМЕРА

Кущенко И.В., Волгин В.В.
В ходе боевых действий на территориях Донецкой и Луганской Народных Республик, а также Запорожской и Херсонской областей, был сильно поврежден жилищный фонд, а также социальные объекты, дорожная сеть и коммунальная инфраструктура

Серёгина Н.Ю., Сербин С.А., Фомин Н.И.
Авторами статьи была разработана и предложена схема взаимодействия с применением технологий информационного моделирования для получения сметной стоимости объектов капитального строительства

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В современных условиях кризисных явлений экономики и повышенной конкуренции товаров и услуг маркетинг играет особую роль во всех сферах деятельности, в том числе и строительной отрасли

Балашов Е.Б.
Доказано, что агрегация больших данных позволяет принимать текущие и стратегические управленческие решения в режиме онлайн и предупреждать на основе комплексной аналитики возможные инциденты, нивелировать их последствия

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Гвоздев Е.В.

В статье рассмотрена проблема управления комплексной безопасностью (далее – КБ) на предприятиях нефтегазового комплекса России

Сезёмин Д.Е.

Материалы представленной научно-исследовательской статьи основаны на анализе методических рекомендаций по повышению организационно-технической надежности проектируемых решений в условиях риска системы на этапе подготовки и основной фазе строительства крупных промышленных комплексов, таких как атомная электростанция

Зайцева Л.И.

Влияние судебной практики на развитие инвестиционно-строительной деятельности и обеспечение бесконфликтной реализации проектов

Балабин Ю.А., Коковин А.Ю., Новожилов В.А.

В сложившихся условиях санкционного давления и кризисных явлений меры государственного регулирования инвестиционно-строительной сферы должны быть нацелены на предотвращение и устранение противоречий и споров между хозяйствующими субъектами, т.е. действенность таких мер подлежит оценке исходя из способности обеспечить условия бесконфликтного строительства

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REAL ESTATE:
ECONOMICS, MANAGEMENT

Scientific and technical journal

Founded in 2001. Published quarterly
Founders: Moscow State University of Civil Engineering (National Research University) (MGSU), ASV Publishing House
The Journal has been included in the list of the leading review journals and editions of the Highest Certification Committee of Ministry of Education and Science of Russian Federation in which the basic results of PhD and Doctoral Thesis are to be published.
The subject matter coverage complies with the approved list of scientific specialties:
5.2.3. Regional and sectoral economics (economic sciences);
2.1.7 Technology and organization of construction (technical sciences);
2.1.10 Environmental safety of construction and urban economy (technical sciences);
2.1.13 Urban planning, planning of rural settlements (technical sciences);
2.1.14 Life cycle management of construction objects (technical sciences).

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Address: MGSU,
26 Yaroslavskoye shosse, Moscow, 129337
Tel.: +7 (968) 903-00-04; e-mail: info@n-eu.ru
On-line version of journal: http://n-eu.iasv.ru/

Signed for printing: 28.12.2023

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During the fighting in the territories of the Donetsk and Lugansk People's Republics, as well as the Zaporozhye and Kherson regions, housing stock, as well as social facilities, road network and communal infrastructure were severely damaged

Seregina N.Yu., Serbin S.A., Fomin N.I.

The authors of the article have developed and proposed an interaction scheme using building information modeling technologies to obtain the estimated cost of capital construction assets

Chernova P.A., Bovsunovskaya M.P.

The list of basic decisions for the implementation of an investment and construction project is mentioned and approved as part of the project documentation. However, the choice and justification of these decisions are made by the customer and the investor already at the pre-design stage

Abdalov R.E., Kulakov K.Yu.

In modern conditions of crisis phenomena of economy and increased competition of goods and services marketing plays a special role in all spheres of activity, including the construction industry

Balashov E.B.

It has been proven that the aggregation of big data makes it possible to make current and strategic management decisions online and to prevent possible incidents based on comprehensive analytics , neutralize their consequences

Sezemin D.E.

Factors that make it possible to evaluate the design of a future building from the standpoint of low-carbon design solutions used (construction resources, space-planning solutions) were identified in the study

UDC 69.05:711.168

Kushchenko I.V.
Volgin V.V.

Spatial and resource development in creating a quality framework for the urban environment of the Donetsk People's Republic

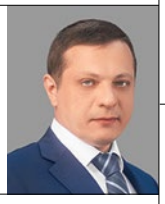
At the time of the actual collapse of Ukraine in 2014, the Donetsk and Lugansk regions together provided about 18 % of all industrial production in Ukraine, and the share of Donbass in the sale of industrial products of the country was higher than any other region.
Based on the Der Spiegel report, as a result of the events of 2014, the following crisis changes occurred in Donbass:

- industry fell by 59 % in Donetsk region and by 85 % in Luhansk region. Production of coke and refined petroleum products decreased by 52.0 %, metallurgical products — by 28.3 %, engineering products — by 22.8 %, electricity, gas — by 18.8 %;
- 69 of 93 coal mines have closed;
- construction in Donetsk region decreased by 37.5 %, in Luhansk region — by 42.4 %;
- 40 thousand small enterprises went bankrupt;
- more than half of the working population has lost their jobs and incomes.

By the end of 2023, the Ministry of Construction plans to restore 7,413 facilities on the territory of the DPR, LPR, Kherson and Zaporizhye regions, 151 of them will have to be built anew. In particular, 4,018 objects are apartment buildings, 39 of which will be built anew, and 238 individual housing construction facilities will also be restored. It is planned to restore 1,625 housing and communal services facilities, among which 78 will be built anew. 951 objects of social, cultural and household use will be restored, 27 will be built, and 7 objects of industrial and entrepreneurial activity will be restored. 402 infrastructure facilities are going to be repaired, 2 will be built from scratch. 68 administrative buildings will be restored, construction of new ones is not planned yet, 22 facilities will be improved. Buildings for 82 multifunctional centres will also be renovated, 7 will be built anew. In total, in the period from 2022 to 2025, there is a plan to restore and build 16,000 facilities during the implementation of a special infrastructure project of the Ministry of Construction of the Russian Federation.
The authors assess the state of the problem of updating and reconstructing the existing urban development.
Keywords: *Renovation, reconstruction, revitalization, restoration of the destroyed housing stock, quality of the living environment, interregional industrial cluster*



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INTRODUCTION

The leading industries in Donbass are metallurgy, mining (coal mining), electric power, mechanical engineering, coke and chemical industries, and the industry for the production of building materials (Table 1) [1].

For industrial facilities in Donbass, in conditions of high anthropogenic load, the wear of structures of buildings and structures, according to experts for various sectors of the economy, amounted to 50–70 % and had a steady trend of further growth.

Table 1. The share of industries in the structure of industrial production

The structure of the industrial complex	Weight, %		
	1977	2014	Specific weight in gross value added
Total industry	100	100	45.0
Mining industry	17.8	15.6	14.7
Processing industry	65.7	68.6	25.3
Including: food industry	7.5	8.2	
light industry	4.7	0.2	
coke production, oil refining	5.2	7.1	
chemical and petrochemical	3.4	4.8	
industry building materials	3.2	2.2	
industry metallurgical production	27.4	33.8	
mechanical engineering	12.8	10.2	
other industries	1.5	1.6	

Before the outbreak of hostilities, Donetsk and Luhansk regions occupied an area of 9.2 % of the total area of Ukraine (53,200 square kilometers). 14 % of the total population of the state lived in Donbass (63 % of it were in the category of able-bodied). The export potential of Donetsk and Luhansk regions in 2013 amounted to $ 16.6 billion, while imports amounted to $ 7.7 billion. The total trade surplus is $ 8.9 billion.

The territories of the former Donetsk and Lugansk regions of Ukraine occupied 25 thousand and 27 thousand square kilometers, respectively. Currently, the LPR and the DPR occupy today about 1/3 of the "initial" areas, located on the most urbanized and industrialized lands. Thus, 15 thousand square kilometers is almost the entire area of the republics of Donbass. According to the estimates of the DPR authorities, as of September 1, 2020, the population of the controlled territories was 2,244,547 people. The territory under the administrative control of the DPR and LPR is small and comparable in area to the smallest regions of Russia. However, the population is very high — more than 3.6 million people in total.

The beginning of the Russian special operation in Donbas was preceded by a humanitarian crisis that lasted eight years. Using heavy weapons, the Ukrainian security forces completely destroyed 19.5 % of the infrastructure of the People's republics of Donbass, up to 37 % of the infrastructure was destroyed with significant damage.

According to data from the DPR, most of the casualties occurred in the first two years of the conflict — 2014 (2,546 people died) and 2015 (1,395 people died) (Fig. 1) [2].

Despite the decrease in the intensity of hostilities, the humanitarian situation worsened as a result of the systematic destruction of civilian infrastructure and facilities protected by the Geneva Conventions of 1949. At the same time, almost daily shelling by the Armed Forces of Ukraine and nationalist battalions caused the destruction of 4,115 and damage to 55,310 infrastructure facilities, including residential buildings, educational institutions, hospitals and many other socially significant facilities. The number of deaths in Donbass has exceeded 14.5 thousand people since 2014 [3]. The Joint Centre for Control and Coordination of Issues Related to War Crimes of Ukraine analyzed data on the destruction (Fig. 2) of infrastructure facilities[1]. As a result of the Ukrainian shelling, by the beginning of the special operation, more than 23 thousand private residential buildings and 5 thousand apartment buildings were destroyed, and individual settlements were virtually wiped off the face of the earth. The damage to the DPR industry due to the shelling of the Armed Forces of Ukraine exceeded 4 billion rubles [4].

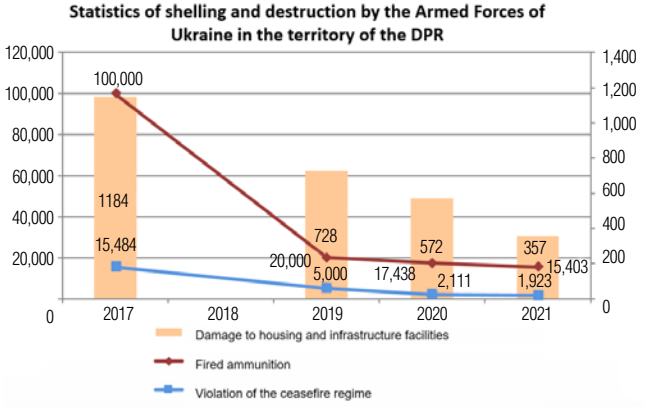


Fig. 2. Data on the destruction of the DPR People's Militia directorate from January 2017 to February 2022

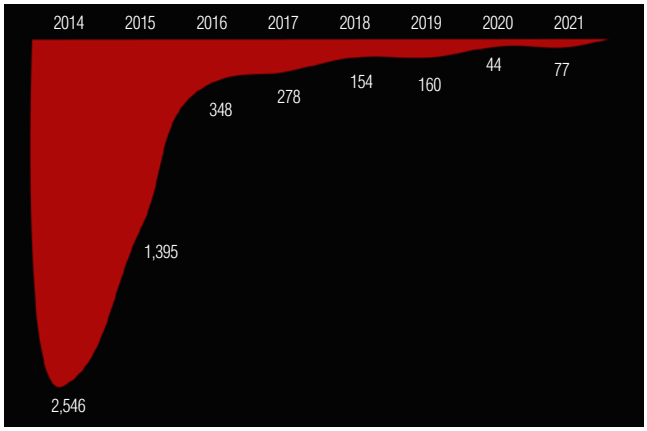


Fig. 1. Statistics of the death of the civilian population of the republic

If 3,166 objects have been destroyed in the republic since April 2014, 1,893 of them are in 2022. In percentage terms, this is approximately 60 % of the total number of destructions over more than eight years [5].

At first, there were about a thousand shelling attacks in Donetsk alone. Accordingly, the amount of ammunition is measured in tens and hundreds of thousands. To date, 837 apartment buildings, more than one and a half thousand private houses, 73 schools, 51 kindergartens have been damaged… [6].

According to the Ministry of Construction and Housing and Communal Services of the DPR, for example, only in Mariupol (Fig. 3) out of the total number of (2,327) multi-apartment residential buildings and (49,343) private residential buildings, 517 multi-apartment buildings and 7,929 private housing buildings are not subject to restoration. There are 261 apartment buildings and 10,802 private houses without damage. The proportion of completely destroyed houses in the city is about 15 % [7].

During the fighting in the territories of the Donetsk and Lugansk People's Republics, as well as the Zaporozhye and Kherson regions, housing stock, as well as social facilities, road network and communal infrastructure were severely damaged. To restore new regions, the Russian construction complex synchronized the efforts of more than 20 federal ministries and departments, 8 federal customers and 56 regional chiefs.



Fig. 3. The destruction of an apartment building that cannot be restored

1 Has Ukraine violated the Minsk agreements? Statistics of shelling and deaths in Donbas according to the DPR. Pikabu. URL: tory/narushala_li_ukraina_minskie_dogovorennosti_statistika_obstrelov_i_smertnosti_na_donbasse_po_dannyim_dnr_10106221 (rus.).

Currently, 1,456 facilities have already been restored with the help of the sponsoring regions. Territories where more than 220 thousand people live are assigned to the subjects of the Far East. Among the protected areas are the cities of Torez, Debaltsevo, Kirovskoye, Shakhtersk, Zhdanovka, Svetlodarsk and the village of Mironovsky, Starobeshevsky and Amvrosievsky districts, the villages of Novoluganskoye and Luganskoye. In accordance with the agreed plan for 2023, work is being carried out at 221 facilities. It is planned to restore 21 schools, 14 kindergartens, 3 hospitals, 11 playgrounds and sports grounds, 25 km of aqueducts, 219.9 km of roads. 13 schools, 9 kindergartens, 3 hospitals, 7 playgrounds and sports grounds, 22 km of aqueducts, 219.6 km of roads have already been restored. Construction and installation works are underway at 23 sites by 8 contractors. Construction and installation works have been completed at 173 sites (78 %), 151 of them (68 %) have been commissioned [8].

HISTORICAL OVERVIEW

Intensive industrial development of the territory of Donbass is associated with the industrial development of Russia in the nineteenth century. During this period, the first geological map of the region was created, industrial coal mining began, which accounted for more than half of the total Russian volume at the beginning of the twentieth century. The availability of its own fuel and energy resources, the proximity of the iron ore deposits of the Krivoy Rog basin, and access to the sea make it possible to establish a metallurgical industry.

In the years of the first pre–war five-year plans, Donbass became a huge construction site, where basic industries are being modernized, mechanical engineering and chemical industry are developing, the first energy facilities, glass and cement plants are being built, etc.

In the territorial structure of the modern industrial complex of the Donetsk region, large industrial formations prevail — production agglomerations and centres concentrating the capabilities of vertically integrated companies of a multidisciplinary orientation and individual specialized enterprises [9, 10].

The *metallurgical complex* is represented by large metallurgical enterprises located in Mariupol, Donetsk, Yenakiyevo, Kramatorsk, Khartsyzsk, Konstantinovka and Druzhkovka. An important link in the functioning of the metallurgical industry is the coke and chemical industry. The leading coke plants are located in Avdeevka, Donetsk, Makeyevka, Yenakiyevo, Gorlovka, Mariupol.

The *coal industry* provides a raw material base for metallurgical, coke chemical and energy production. Most coal mining enterprises were developed during the Soviet period and require restructuring and modernization.

Thermal power plants are provided mainly with their own coal, which fully meets the needs of industry and the population. The largest producers of electricity are thermal power plants, including Uglegorskaya, Starobeshevskaya, Slavyanskaya, Kurakhovskaya, Zuyevskaya, Kramatorskaya. A wind power plant has been built in the Novoazovsky district, on the coast of the Azov Sea, representing an alternative development of electricity production methods.

The *machine-building base* of the Donetsk region was formed during the Soviet period, includes a full cycle of technological production, which is a decisive factor in the technical re-equipment of the coal and metallurgical complex. The product range of machine-building enterprises, among which the most significant are Azovmash, Mariupol Heavy Machinery Plant, Novokramatorsky Machine-Building Plant, Energomashspetsstal, Donetskgormash, Gorlovsky Mashinostroitel, includes metallurgical, hydraulic engineering, mining, lifting and transport equipment and specialized equipment for the leading sectors of the region's economy, the Middle East and far abroad.

Thus, the industrial and technological development of the Donetsk region contributed to the structural formation of the Donetsk-Makeyevka industrial agglomeration and Kramatorsk-Slavyansk, Krasnoarmeysky, Gorlovsko-Yenakiyevsky, Torezo-Snezhnyansky and Mariupol industrial districts.

The *branches of the fuel and energy complex, metallurgy and mechanical engineering* are of predominant importance for the economy of the region, which determine its position and importance in the system of territorial division of labor.

During the economic crisis of the 1990s, the largest reduction in production was observed in the manufacturing industry, especially in mechanical engineering and light industry. At the same time, the extractive industries and primary processing of raw materials have increased their share in industrial production. Changes in the industrial structure of the industry are also due to physical wear and aging of equipment, which has affected the upper floors of the industry, producing technically complex products. At the beginning of 2014 the degree of depreciation of fixed assets in the group of industries producing minerals exceeded 53 %, in manufacturing industries — 46 %, and in industries engaged in the production and distribution of electricity, gas and water — 52 %.

ENSURING THE IMPLEMENTATION OF THE PROGRAMME OF CONSTRUCTION, RECONSTRUCTION, REVITALIZATION, MAJOR REPAIRS AND DEMOLITION OF THE DESTROYED HOUSING STOCK

An important direction for the development of the DPR in 2023 is the continuation of work on economic development and attracting investments. Events to support small and medium-sized businesses, as well as to stimulate innovation, are of great importance. The Ministry of Construction and Housing and Communal Services of Russia has developed a master plan for the development of the Donetsk People's Republic, the priority concept of which will be the restoration, construction of housing and life-supporting social infrastructure. It is planned to ensure the development of project financing of housing construction using government support measures, private housing construction, to ensure the creation of road and communal infrastructure, and to expand the use of mortgages.

Despite the damage caused by the destruction as a result of rocket and artillery strikes on basic (industrial) enterprises (Fig. 4), the Government of the Russian Federation and the DPR set the task to revive the former productive and industrial power of the region so that residents who were forced to leave earlier return home to live and work [4].

As structural elements of the programme of reconstruction and renewal of the existing urban development, it is advisable to develop regulatory, urban planning, economic, financial, organizational and managerial blocks. All blocks are in a causal relationship that determines the sequence of their formation (Fig. 5).

The problem of implementing the urban renewal project programme related to achieving this goal can be divided into several components:

- *functional*, which reflects the main content of the programme, representing various options for the reproduction of individual elements, aggregates of elements and the land and property complex as a whole;



Fig. 4. Destruction of the industrial infrastructure of Donbass

- *providing*, mainly related to the development and organization of the functioning of the mechanism of economic relations between participants in the investment process, financing and management of programme activities.

The totality of all these real estate objects is the task of forming a portfolio of urban real estate, including real estate for various purposes (housing, office space, land, city rights, etc.).

Portfolio optimization consists of two stages:

- choosing the optimal combination of risky assets;
- combining the obtained optimal set of risky assets with risk-free assets.

Currently, a situation has arisen in the DPR housing market caused by certain difficulties in implementing the city's real estate renovation and new housing construction programme. The reasons for this situation are objective and are related (Fig. 6):

- to high prices for residential real estate;
- with increasing competition in the housing market;
- with the increase in demand for residential real estate in relation to supply;
- with the possibility of purchasing housing only for high-income segments of the population.

Data processing by the method of variant modeling has shown that about 65 % of families express firm confidence in the need to improve their living conditions, of which:

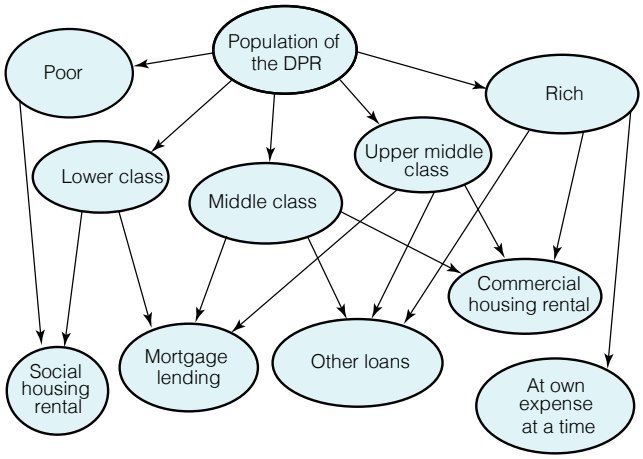


Fig. 6. Possible options for categories of citizens to purchase housing and consumer preferences

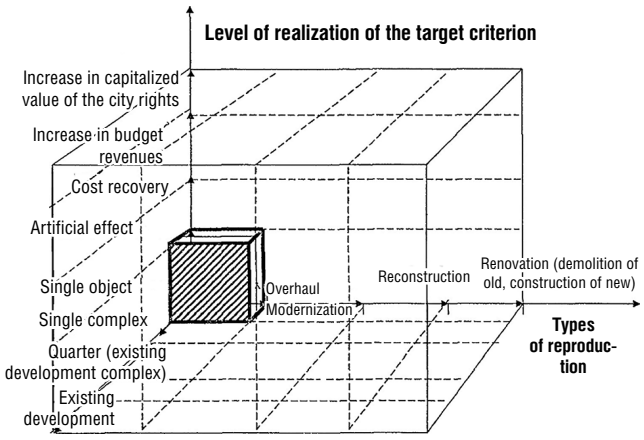


Fig. 5. The decomposition structure of the Programme [15]

- group of “poor” and “lower middle class” — about 70 %;
- “middle class” group — about 25 %;
- “upper middle class” group — about 4 %;
- “rich” group is less than 0.5 %.

Thus, the housing problem, as the analysis shows, concerns primarily the poor, the lower and middle classes.

The quality of the living environment determines the socio-economic development of a society both at the national level and on a city scale. The main criterion for assessing the quality of the living environment is to ensure a safe and accessible environment for all categories of citizens.

PROGRAMME-TARGETED MANAGEMENT OF THE RENOVATION OF EXISTING URBAN RESIDENTIAL BUILDINGS

The implementation of programme-oriented management methods in the Donetsk People's Republic entails the need for a detailed study of the features of spatial development of territories that have a significant impact on current socio-economic processes (Fig. 7)[2] [12–15].

The analysis of demographic processes indicates that the population of the Donetsk People's Republic is increasingly concentrated in cities. In particular, by the end of 2018, the urban population amounted to 95 % of the total available population, including 79 % living in such large cities as Donetsk, Horlivka, Makeyevka, Yenakiyevo and Khartsyzsk. In this regard, problems in the operation of engineering and communal infrastructure are increasing; uneven distribution of material objects is traced; congestion of the road network and the social sphere is noted. Under the current conditions, the priority area of activity is the integrated development of territories through the development of new management mechanisms while increasing its competitiveness and investment attractiveness [16–19].

The Ministry of Construction of the DPR and the Unified Institute of Spatial Planning of the Russian Federation are engaged in substantiating the mechanism for using the Integrated Territorial Development Tool (ITD). As an example, we can cite the experience of developing urban planning documents for the central part of the city of Mariupol in the Raketa microdistrict. In total, four sites are

2 URL: https://mer.govdnr.ru/index.php?option=com_content&view=article&id=6962:prostranstvennye-osobennosti-razvitiya-gorodov-i-rajonov-respubliki&catid=40&Itemid=665 (rus.).

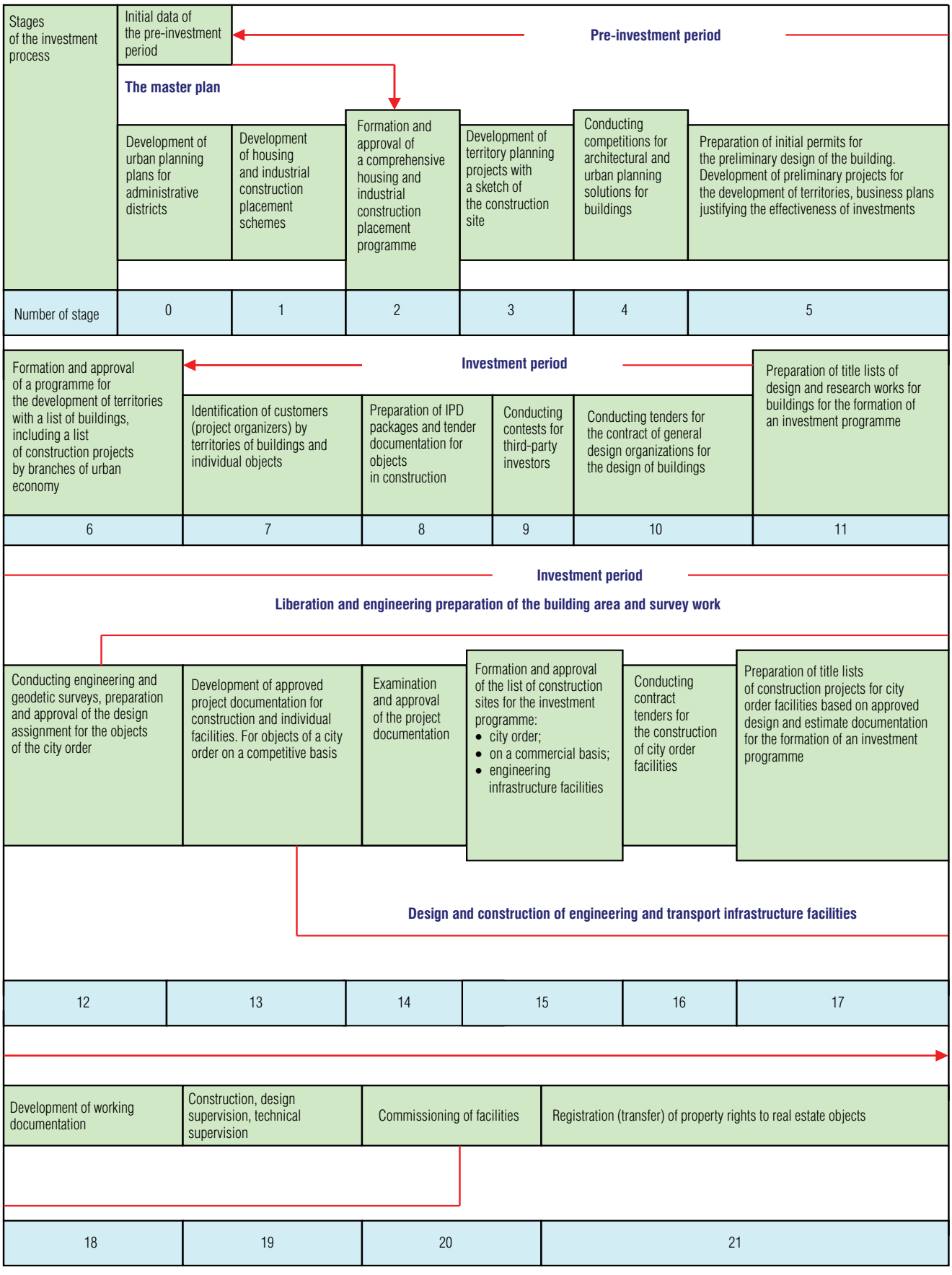


Fig. 7. Investment urban programme of construction, revitalization and major repairs in the cities of Donbass

being considered for the integrated development of territories in the DPR and the Zaporozhye region [20–22].

Residents of Donbass through the implementation of the programme will receive:

- modern, high-quality, comfortable conditions;
- the opportunity to improve your living conditions at an affordable price;
- minimizing the costs and inconveniences associated with relocation and major repairs;
- the ability to effectively influence the processes of complex reconstruction of existing buildings and the operation of housing stock.

The organization of programme management is determined by the following aspects.

In the organizational and functional structure of the process of complex reconstruction of the existing buildings, three main blocks of functions are sequentially distinguished:

- city regulation;
- investment and construction works;
- exploitation of the territory.

CONCLUSION

World experience shows the advantages of the cluster approach for a constructive dialogue between representatives of the business sector and the state. In the context of the recovery of the industrial sector of the region, the investment strategy involves increasing the effectiveness of interaction between the private sector, the state, trade associations, research and educational institutions in the innovation process. The cluster participants are characterized by cooperation and territorial concentration. In order to boost production, enterprises need profitable cooperative ties that have historically existed since the Soviet period. We cannot do without them, as our enterprises have been drained of both financial and human resources.

Currently, the first interregional industrial cluster in Russia, "KEMZ", is being created in Kemerovo with the participation of enterprises of the DPR and the Tomsk region. The Kemerovo machine-building cluster should include about 10 companies from the DPR, Kemerovo and Tomsk regions specializing in mechanical engineering for the mining industry. The task of the cluster is the implementation of projects providing for the development of components for equipment designed for vertical, horizontal underground mining and metro.

Small towns of the DPR open up wide opportunities for the implementation of bright and functional projects for the formation of a modern urban environment. Since joining Russia, one of the main tasks is to restore and bring the existing urban infrastructure to the national average. Of the 27 cities within the current borders, 23 belong to small towns. More than 500 thousand people live in them, and more than a third of the population is in their zone of influence. To participate in the All-Russian competition, the regional Interdepartmental commission sent projects of 14 cities to the Ministry of Construction of the Russian Federation for consideration. According to the results of the VIII Competition of the best projects for the formation of a comfortable urban environment, the submitted works were selected by experts in the field of architecture, urban planning, economics, sociology of cultural heritage protection, archeology. Among the 145 winners, three projects from the DPR received support: landscaping in Volnovakha — the Revival of the Summer Park; landscaping of the city centre Snezhnoye; landscaping of the square near the monument to V. Lenin in Shakhtersk.

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Пространственно-ресурсный девелопмент в создании каркаса качества городской среды Донецкой Народной Республики

На момент фактического распада Украины в 2014 г. Донецкая и Луганская области в совокупности обеспечивали около 18 % всего промышленного производства Украины, а доля Донбасса в реализации промышленной продукции страны была выше, чем любого другого региона.

Исходя из доклада Der Spiegel, в результате событий 2014 г. в Донбассе произошли следующие кризисные изменения:

- промышленность упала на 59 % в Донецкой области и на 85 % в Луганской. Сократилось производство кокса и продукции нефтепереработки на 52,0 %; металлургической продукции — на 28,3 %; машиностроительной продукции — на 22,8 %; электроэнергии, газа — на 18,8 %;
- закрылись 69 из 93 угольных шахт;
- строительство в Донецкой области обвалилось на 37,5 %, в Луганской области — на 42,4 %;
- обанкротилось 40 тыс. малых предприятий;
- больше половины работоспособного населения потеряло работу и доходы.

До конца 2023 г. Минстрой планирует восстановить 7413 объектов на территории ДНР, ЛНР, Херсонской и Запорожской областей, из них 151 придется строить заново. В частности, 4018 объектов — это многоквартирные дома (МКД), 39 из которых будут строиться заново, также восстановят 238 объектов индивидуального жилищного строительства. Планируется восстановить 1625 объектов ЖКХ, среди которых 78 будут построены заново. 951 объект социально-культурного и бытового назначения (СКБ) восстановят, 27 построят, а также восстановят семь объектов производственно-предпринимательской деятельности. Отремонтировать собираются 402 объекта инфраструктуры, два построят с нуля. Восстановят 68 административных зданий, строительство новых пока не планируется, благоустроят 22 объекта. Также будут отремонтированы здания под 82 МФЦ, два построят заново. Всего в период с 2022 по 2025 г. существует план восстановить и построить 16 000 объектов в ходе выполнения специального инфраструктурного проекта Минстроя РФ.

Авторы оценивают состояние проблемы по обновлению и реконструкции сложившейся застройки города.

Ключевые слова: *обновление, реконструкция, ревитализация, восстановление разрушенного жилищного фонда, качество жилой среды, межрегиональный промышленный кластер*

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For citation: Kushchenko I.V., Volgin V.V. Spatial and resource development in creating a quality framework for the urban environment of the Donetsk People's Republic. *Real Estate: Economics, Management*. 2023; 4:6-12.

Для цитирования: *Кущенко И.В., Волгин В.В.* Spatial and resource development in creating a quality framework for the urban environment of the Donetsk People's Republic // Недвижимость: экономика, управление. 2023. № 4. С. 6–12.

UDC 69.009.1

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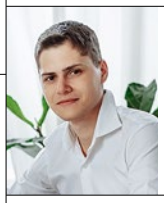
Improving the organizational scheme for conducting state examination of design documentation in order to obtain a reliable estimated cost using BIM

The organizational possibilities of resolving the problem of discrepancy between the estimated and actual costs of capital construction assets by dividing the process of state expertise into two organizational phases: checking the design solution of a capital construction project and assessing the reliability of the estimated cost were explored. The authors conducted an expert analysis of the current number of capital construction projects based on a survey of an expert group. The assessment revealed that on average 59.5 % of capital construction assets per year, financed from the state and municipal budgets, have more than 2 % discrepancy between the estimated cost at the stage of architectural and construction design and the actual cost of construction. The labour costs of specialists from the Ministry of Construction and Infrastructure Development of the Sverdlovsk Region were assessed if it was necessary to adjust budget programmes. The current scheme of interaction between participants in the construction process was formed, on the basis of which problem phases were identified. In problem phases, there is an information gap between the detail of the building information model necessary for the examination of design solutions and for assessing the reliability of the estimated cost of a capital construction asset. The authors of the paper have developed and proposed an interaction scheme using building information modelling technologies to obtain the estimated cost of capital construction assets eliminating the information gap by dividing the state examination process into two phases and calculated the difference in the time costs of processes in both schemes that is 51 days. It was proposed to make adjustments to the legislation with the approval of the examination process in two phases, as well as the approval of unified requirements for building information models for the implementation of the proposed scheme and the introduction of building information modelling technologies into the state examination process.

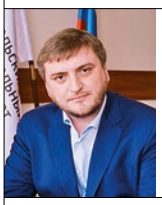
Keywords: *building information modelling (BIM) technologies, building information model, state examination, design documentation, reliable estimated cost, life cycle of capital construction objects*



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INTRODUCTION

The introduction of building information modelling technologies into construction and investment design processes is becoming increasingly popular in our country. For various reasons, Russia is currently an objectively "catching up" country in the large-scale development of building information modelling technologies (BIM) implementing according to the "top-down" scheme [1]. Recently, this approach was adopted in the UK, where the British Standards Institute began to develop standards for building information modelling technologies in 2007 [2], and the government launched the process of implementing building information modelling in 2010, gradually adding the requirements until the release of requirements for all facilities financed by the state in 2016 [1, 3, 4]. The UK is now widely recognized as a world leader in the field of building information modelling technologies standards and guidelines.

In our country, the stagnation in the level of BIM development and the redistribution of resources was facilitated by a forced market shift towards domestic vendors, while the majority of the market was occupied by foreign software systems [5]. The more active BIM implementation is facilitated by the current editions of regulatory documents [6], [7], as well as past editions of the government regulations [8], the current version of which is currently at the development stage. The listed documents contain necessary requirements to develop a building information model, its composition and a description of the conditions when it is necessary to generate building information models. Thus, the large-scale application of building information models at all stages of the asset life cycle becomes almost inevitable in the future, despite the typical difficulties of BIM implementation [9].

At the same time, the necessity of developing building information models entails not only an increase in labour costs for their creating, but also the models can provide solutions to applied problem tasks of construction organizations, including the development of design solutions and their expertise. To achieve these goals, general requirements for building information models have been proposed in various documents already in force [10], [11] or emerging [12]. However, the process of conducting state examination at the stage of architectural and construction design is not fully adapted to the use of building information models when checking project documentation.

The current version of the Government Decree [13] provides for fundamental solutions for sections of the design documentation: standard structural units, lack of reinforcement, finishing sheets only in a tabular form, schematic diagrams of engineering systems. In this case, a specialist of an expert institution, in the process of examining design documentation, must obtain and analyze an array of necessary information to assess the reliability of the estimated documentation according to [14].

Thus, objectively, there is an information gap due to the different requirements for level of detail sections of design documentation according for [13] and the information necessary to assess the reliability of the estimated cost. It is obviously that it is impossible to prepare the specification necessary for drawing up an estimate based on a typical unit or schematic diagram. At the same time, on the one hand, a building information model is not able to contain a table with data, since it does not have a three-dimensional representation in a real object; on the other hand, it is not able to contain elements by which a specification can be formed, since then the composition of detail of the design documentation dictated [13] will be exceeded. This means that the requirements for the building information model in one situation will contain excessive information on [13], in another situation there will be insufficient information for the requirements [14].

Thus, specialists who carry out the examination of design documentation are faced with the problem of the lack of an unambiguously described scheme of interaction between participants in an investment and construction project at the stage of architectural and construction design using building information modelling technologies. As a result, an ordinary specialist, being a participant in the construction process in the field of determining the estimated cost at the stage of architectural and construction design, tries to avoid using of building information models due to the uncertainty of his responsibilities and specific tasks when working on a building information model.

Based on the main fundamental tasks of building information modelling technologies, accuracy, leading to a reduction in the risk of price increases, is the most crucial among them [15]. However, despite the use of building information modelling technologies, due to insufficient detail of the building information model at the time of the examination, there is an information gap between the level of the graphic part detail of the design documentation, which is necessary to assess the reliability of the estimated cost at the stage of architectural and construction design, and the graphic part detail of the design documentation in accordance with the requirements [13]. Therefore, at the stage of working documentation and clarification of the project, it may be necessary to recalculate the volumes of elements that were in the work volume statement of quantities or specifications, but were not present in the building information model. In case of an unfavourable outcome, having an underestimated project cost, the technical customer faces problems in the form of failed tenders, time costs associated with adjustments to the design documentation, and this also becomes one of the reasons for the emergence of unfinished construction projects.

METHODS

The authors formed an expert group consisting of the representatives of the Ministry of Construction and Infrastructure Development of the Sverdlovsk Region, municipal customers, such as the Capital Construction Department of Yekaterinburg, the Capital Construction Department of the Sverdlovsk Region. The group also included experts from the State Autonomous Institution of the Sverdlovsk Region "Department of State Expertise". The participants of the expert survey, based on professional experience, had to indicate the percentage of construction assets per year, for which the discrepancy between the estimated cost at the design stage and the actual construction costs was less than 2 %, from 2 to 5 % and from 5 to 10 %. According to the results, it was found that about 59.5 % of construction assets from the extensive combined experience of experts have a discrepancy in the estimated cost of more than 2 %. The graph of the survey results is shown in Fig. 1.

To assess the statistical significance of the results obtained, the Pearson test was applied. It was hypothesized that among experts' opinions, the average percentage value of projects with a cost difference exceeding 2 % is a statistically correct value.

According to Table 1, this value is 59.5 %. The measure of the dispersion was determined using the Pearson method using X_i-square statistics according to formula (1):

$$X_n^2 = \sum_{i=1}^{n} \frac{(O_i - E_i)^2}{E_i}, \quad (1)$$

were O_i — the result according to experts (sum of columns 3 and 4 of Table 1);

E_i — expected result (in our case, 59.5 % was chosen).

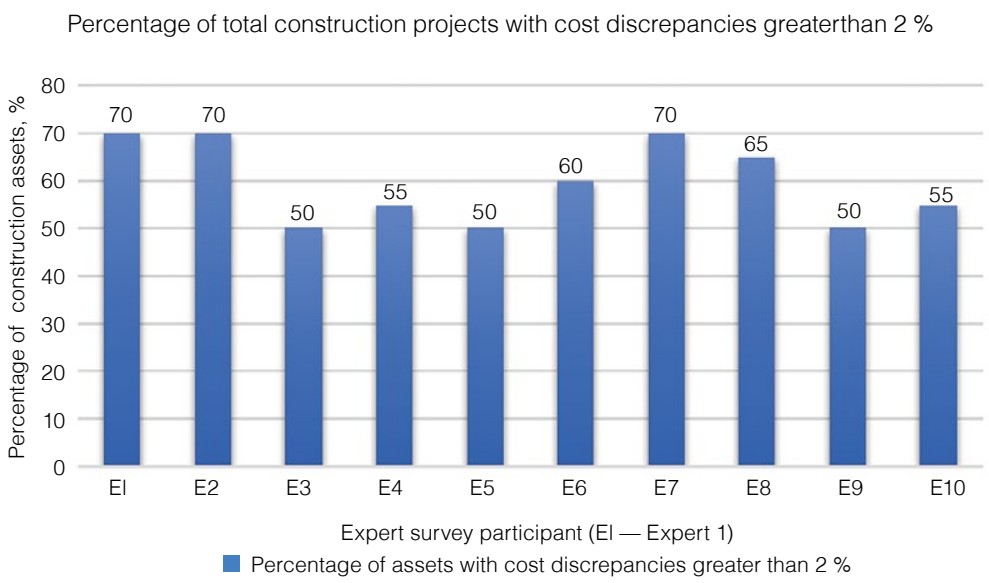


Fig. 1. Results of an expert study on the discrepancy between the estimated cost of construction assets and actual costs

Table 1. The percentage of construction assets per year depending on the discrepancy between the estimated cost at the design stage and the actual construction costs according to the expert group opinion

Expert's number	Less than 2 %	From 2 to 5 %	From 5 to 10 %
1	30	35	35
2	30	50	20
3	50	25	25
4	45	25	30
5	50	40	10
6	40	40	20
7	30	40	30
8	35	50	15
9	50	30	20
10	45	20	35
Average, %	40.5	35.5	24

$$X_n^2 = \frac{(70-59.5)^2}{61.5} + \frac{(70-59.5)^2}{61.5} + \frac{(50-59.5)^2}{61.5} + \frac{(55-59.5)^2}{61.5} + \\ + \frac{(65-59.5)^2}{61.5} + \frac{(55-59.5)^2}{61.5} + \frac{(50-59.5)^2}{61.5} = 14.5.$$

Further, the obtained statistics were compared with the critical value at 9 degrees of freedom k and a significance level of 0.05 (α) according to the table of critical values of the X_i-square distribution, that is, with 16.91898. Since 14.5 < 16.91898, the initially selected value of 59.5 % can be considered statistically significant.

The coefficient of concordance of expert opinions was also calculated to assess the consistency of opinions using formula (2):

$$W = \frac{12\sum_{i=1}^{n}(O_i - E_i)^2}{m^2(n^3 - n)}, \quad (2)$$

were m — a number of experts;

n — a number of selected objects (in our case 3).

$$\sum_{i=1}^{n}(O_i - E_i)^2 = (70-59.5)^2 + (70-59.5)^2 + (50-59.5)^2 + \\ + (55-59.5)^2 + (50-59.5)^2 + (60-59.5)^2 + (70-59.5)^2 + \\ + (65-59.5)^2 + (55-59.5)^2 + (50-59.5)^2 = 862.5;$$

$$W = \frac{12 \cdot 862.5}{10^2(3^3 - 3)} = 4.31.$$

So, the consistency was checked using the Pearson criterion by the formula (3):

$$W \cdot k \cdot n = 4.31 \cdot 9 \cdot 10 = 388.125 > 16.91898. \quad (3)$$

The experts' opinions are consistent. Thus, the hypothesis that the value of 59.5 % of construction assets that have a discrepancy in estimated cost of more than 2 % was found to be statistically significant and accepted for further research.

The discrepancy between the estimated and actual costs of two out of three capital construction assets reduces the accuracy of budget expenditure planning, which can lead to disruption of the planned implementation of large state and municipal programmes. To assess the consequences of the failure, the authors used an analysis of the labour costs of specialists from the Ministry of Construction and Infrastructure Development of the Sverdlovsk Region in case of necessity to increase the cost of the project. The results of the analysis are visible in the diagram presented in Fig. 2.

To adjust the budget programme, a total of 50 days of specialist work are required. It can be avoided with a correct assessment of the reliability of the estimated cost, which in turn is achieved by

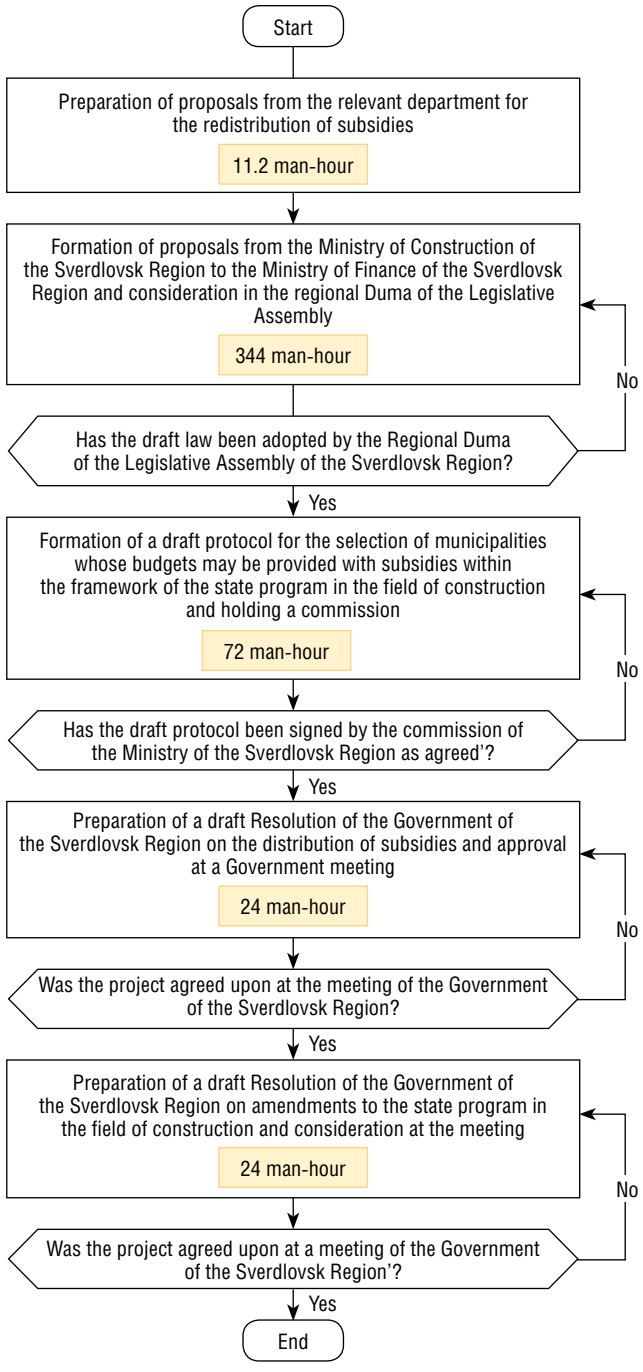


Fig. 2. Scheme for adjusting budget programmes taking into account the labour costs of specialists

a clearly described organizational scheme of interaction between participants in an investment and construction project using building information modelling technologies.

Thus, the authors of the paper formed the following goal of the study — to propose an organizational scheme for interaction between participants in an investment and construction project, which includes the use of building information modelling technologies and makes it possible to unambiguously describe the process of conducting an examination of design documentation, taking into account the assessment of the reliability of the estimated cost.

To achieve this goal, a couple of tasks were formed:

1. Describe the current organizational scheme of interaction between the participants of an investment and construction project and determine the deadlines for each stage using the example of an actually constructed facility in Yekaterinburg.
2. Identify the stages of the organizational scheme, at which there is an information gap between the attributive content of the sections of the design documentation and the possibility of generating on its basis lists of quantities and specifications to assess the reliability of the estimated cost.
3. Identify the stages the timing of which is increasing due to the identified problems.
4. Develop an organizational scheme for interaction between participants in an investment and construction project in order to eliminate the information gaps that arise today and, as a result, extended deadlines.

As a result of the analysis of the interaction of participants in the investment and construction project using on the example of preschool educational institution No. 1 with nursery groups in block No. 11 of the Akademichesky district in the city of Yekaterinburg, the diagram presented in Fig. 3 was formed.

In accordance with the current scheme design documentation is developed using building information modelling technologies and simplified detailing, then a state examination is carried out and a cost limit is determined. Next, a tender purchase is carried out for the development of working documentation and further construction of the asset. It often happens that the state customer has to re-execute the tender purchase, because they are not able to find a contractor. After that, taking into account the discrepancy in the volumes identified during the preparation, the working documentation is adjusted and sent for re-examination. Then construction is carried out and at this stage there are often time costs associated with procedural work to increase the cost of asset construction, such as acts of additional work and others, which leads to the necessity of implementing the diagram in Fig. 2.

After a thorough analysis of the current organizational interaction scheme, the following problematic stages were identified.

At the stage of the state examination, an information gap occurs between the information content of sections of the design documentation and the possibility of forming on its basis statements of quantities and specifications to assess the reliability of the estimated cost, since the use of a building information model is unreasonable either at the stage of fulfilling the conditions of technical regulations due to oversaturation of information, or at the stage of verifying the accuracy of the estimated cost due to the lack of information content. As a consequence, delays in terms of searching for a contractor occur at the stage of the tender procurement due to undervaluation and the need for repeated

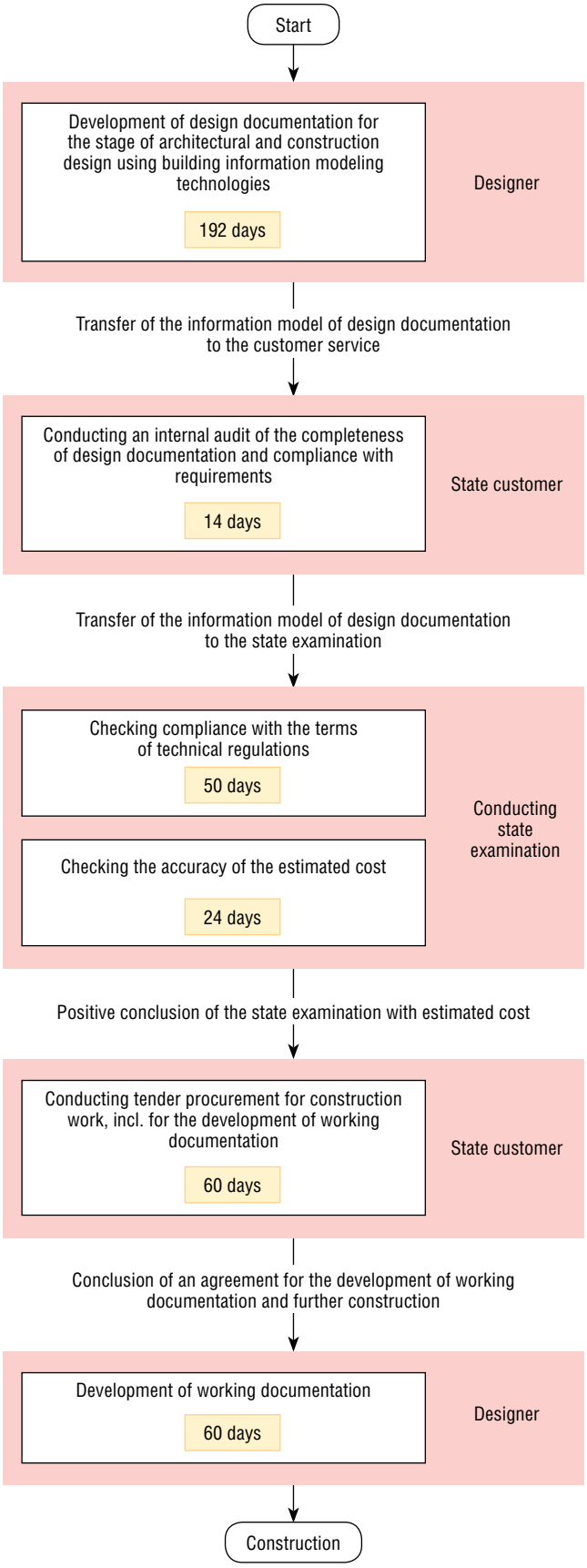


Fig. 3. The current scheme of interaction between participants in the investment and construction project

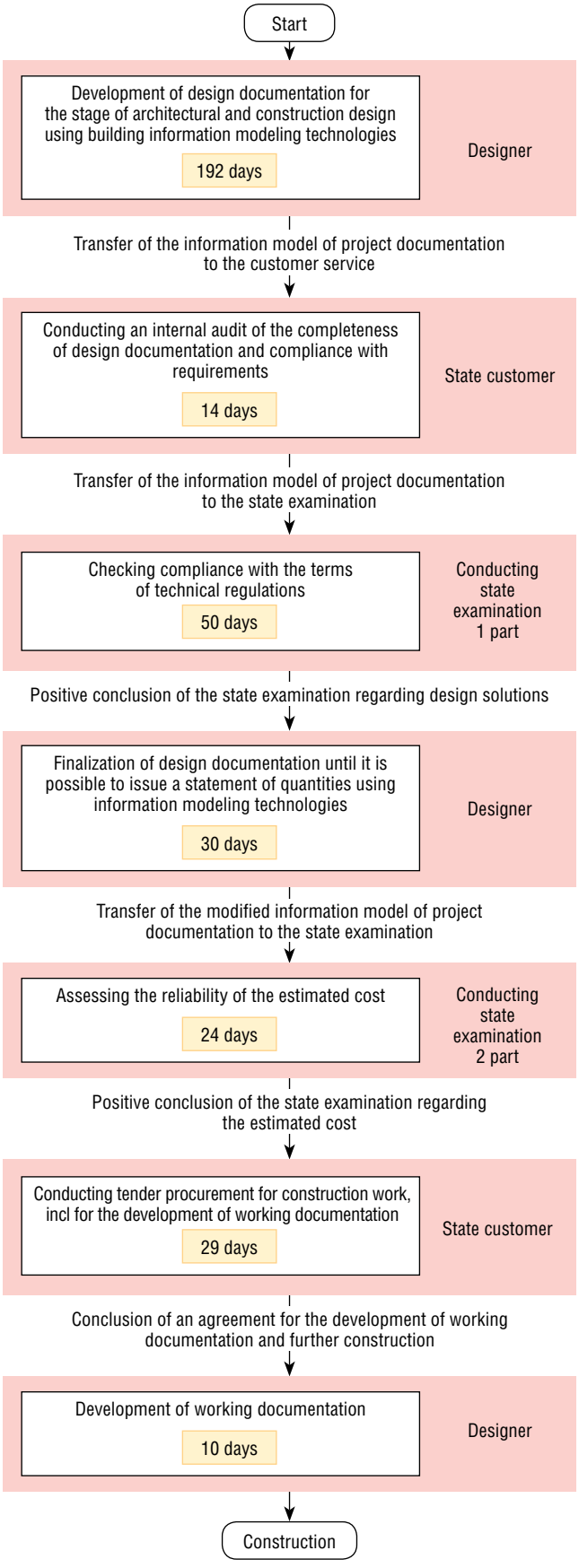


Fig. 4. Proposed scheme of interaction between participants in the investment and construction project

tenders, which also leads to additional labour costs described in Fig. 2 at the construction stage.

The information gap in the current interaction scheme occurs due to the fact that the design documentation is submitted once for state examination, and therefore for verification of design solutions and assessment of the estimated cost reliability. However, the detail required to accomplish these tasks varies. The information content of the building information model necessary to verify design solutions can be generated on the basis of the composition specified in the annex to the Government Decree [13], [16]. However, in order to assess the reliability of the estimated cost, it is necessary to be able to generate bills of quantities and specifications from a building information model, which requires additional detail from it and bringing the level of elaboration closer to the stage of working documentation due to elements such as utility networks instead of schematic diagrams, wall finishing elements instead of information about the belonging of the finishing to the premises and others. Thus, it is proposed to divide the state examination into two stages corresponding to the ongoing inspections. The scheme proposed by the authors is shown in Fig. 4.

RESULTS

To carry out an examination of design solutions for compliance with the requirements of technical regulations, it is proposed to perform a building information model for filling that meets the requirements specified in [13], without additional detail. Experts from technical departments express a positive opinion on the design documentation of the architectural and construction design stage in terms of technical regulations. This process can be implemented within the framework of expert support according to [14]. Next, the model is finalized by the designer, during which the building information model is filled with a list of parameters that is minimal and sufficient to assess the reliability of the values from the bills of quantities and specifications, thereby bringing the model detail to 80 % of the working documentation stage. After that, a re-examination of compliance with the requirements of technical regulations is carried out, and changes made to the approved version are monitored. Further, such a model is sent to the estimate department to assess the reliability of the estimated cost, which becomes possible thanks to its detail. Thus, the information gap identified in the current interaction scheme is closed. Due to the fact that the reliability of the statements of quantities of work is checked automatically, the accuracy of the calculation increases, therefore, the time costs associated with re-searching for a contractor are eliminated, which means the time for conducting a tender purchase is halved. Moreover, the costs associated with budget reallocation indicated in Fig. 2 are also excluded, since bills of quantities and specifications are controlled using automated 3D model checks.

Thanks to the division of the process of conducting state examination of design documentation into two stages (Fig. 5): verification of design solutions and assessment of the reliability of the estimated cost, the detail of the building information model is not a contradiction [13] and [14] at each stage.

When estimating the total duration of mandatory processes before the start of construction work, savings are also obtained. Under the current scheme of interaction between participants, the total duration of the processes is 400 days, while under the proposed scheme this duration is 349 days. As a result, the construction of an asset can be started 51 days earlier due to a reduction in the time required to verify the scope of work,

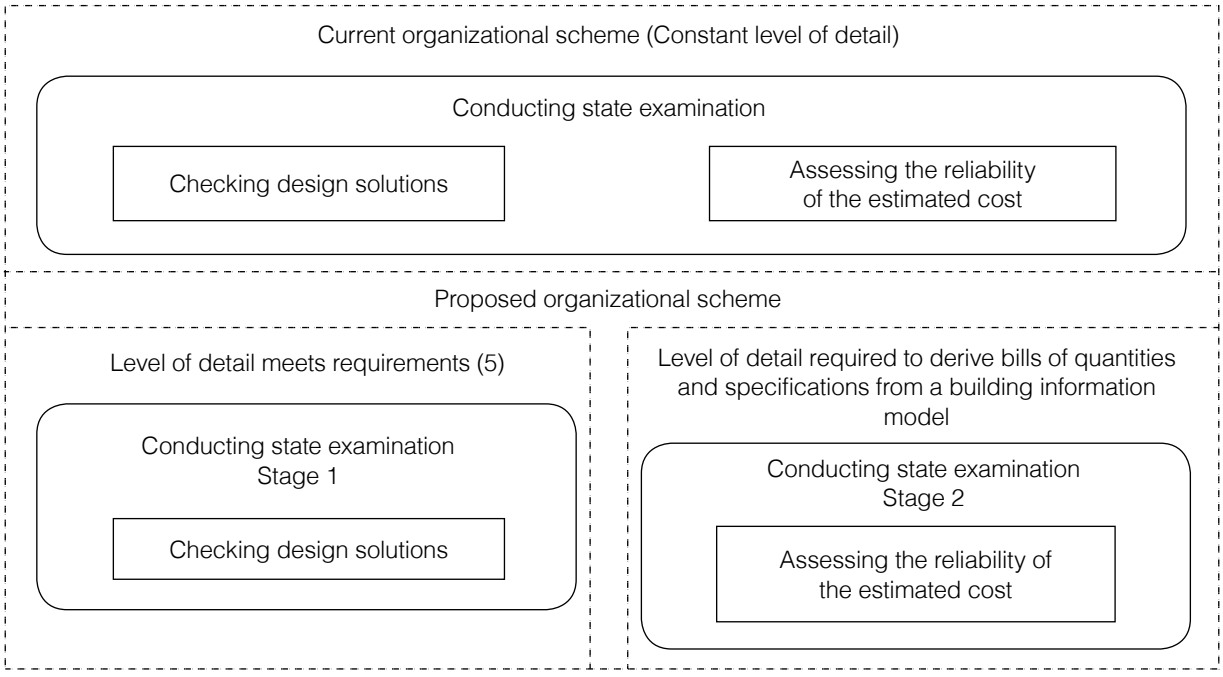


Fig. 5. Dividing the process of state examination into 2 stages

eliminating problems during tender procurement and eliminating the need for re-examination.

It is worth mentioning that nowadays, the implementation of the planned interaction scheme is possible only with legislative support, since despite the problems described in the paper when using building information modelling technologies, the requirements for the composition of design documentation [13] are mandatory and cannot be expanded without adjusting the legislation. Conducting a state examination in two stages is also not currently legally justified and can only be implemented as part of the expert support process. Therefore, for the further implementation of the research results, it is necessary to legitimize the requirements for building information models used in assessing the reliability of the estimated cost, as well as conducting a state examination in two stages, taking into account the increasing detail of the building information model.

CONCLUSION

The authors of the paper, during an expert survey, found out that on average 59.5 % of construction assets have a discrepancy in estimated cost of more than 2 %. The current scheme of interaction between participants in an investment and construction project was developed and the problematic stages of such a scheme were identified, related to the information gap between the detail of the graphic part of the design documentation necessary to assess the reliability of the estimated cost at the stage of architectural and construction design and the detail of the graphic part of the design documentation in accordance with the requirements [13]. The consequences of the presence of an information gap were analyzed, such as conducting a repeated tender purchase and the need for a repeated state examination. Based on the obtained results the duration of all stages was estimated.

The authors proposed an interaction scheme that divides the state examination process into two stages: verification of design solutions and assessment of the reliability of the estimated cost, allowing to avoid the emergence of an information gap. The application of the scheme helps to eliminate the consequences of the information gap identified in the current scheme, and makes it possible to reduce the duration of mandatory processes before construction work by 51 days. The need for legislative adjustments to implement the proposed organizational scheme was also described.

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Разработка схемы взаимодействия участников строительного процесса с целью получения достоверной сметной стоимости на этапе проведения государственной экспертизы проектной документации с помощью технологий информационного моделирования

В работе были исследованы организационные возможности разрешения проблемы несоответствия сметной и фактической стоимости объектов капитального строительства за счет разделения процесса проведения государственной экспертизы на два организационных этапа: проверки проектных решений объекта капитального строительства и оценки достоверности сметной стоимости. Авторами была проведена экспертная оценка текущего количества объектов капитального строительства на основании опроса экспертной группы, в ходе которой было выявлено, что в среднем 59,5 % объектов капитального строительства в год, финансируемых из государственного и муниципального бюджета, имеют более 2 % расхождения между сметной стоимостью на этапе архитектурно-строительного проектирования и фактической стоимостью строительства. Была проведена оценка трудозатрат специалистов Министерства строительства и развития инфраструктуры Свердловской области при необходимости корректировки бюджетных программ. Была сформирована действующая схема взаимодействия участников строительного процесса, на основании которой выявлены проблемные участки, на которых происходит информационный разрыв между детализацией цифровой информационной модели, необходимой для экспертизы проектных решений и для оценки достоверности сметной стоимости объекта капитального строительства. Авторами статьи была разработана и предложена схема взаимодействия с применением технологий информационного моделирования для получения сметной стоимости объектов капитального строительства, исключающая информационный разрыв за счет разделения процесса государственной экспертизы на два этапа, и рассчитана разница временных издержек процессов обеих схем, которая составляет 51 день. Было предложено внесение корректировок в законодательство с утверждением проведения процесса экспертизы в два этапа, а также утверждение единых требований к цифровым информационным моделям для реализации предложенной схемы и внедрению технологий информационного моделирования в процесс государственной экспертизы.

Ключевые слова: *технологии информационного моделирования, цифровая информационная модель, государственная экспертиза, проектная документация, достоверная сметная стоимость, жизненный цикл объектов капитального строительства*

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For citation: Seregina N.Yu., Serbin S.A., Fomin N.I. Improving the organizational scheme for conducting state examination of design documentation in order to obtain a reliable estimated cost using BIM. *Real Estate: Economics, Management*. 2023; 4:13-20.

Для цитирования: *Серёгина Н.Ю., Сербин С.А., Фомин Н.И.* Improving the organizational scheme for conducting state examination of design documentation in order to obtain a reliable estimated cost using BIM // Недвижимость: экономика, управление. 2023. № 4. С. 13–20.



Москва. Улица Петровка. Рисунок, тушь перо

UDC: 69.003.13

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Improvement of methods for determining the cost of design solutions at early stages of investment and construction projects realization

The list of basic solutions for the implementation of an investment and construction project is mentioned and approved as part of the project documentation. However, the choice and justification of these decisions are made by the customer and the investor already at the pre-design stage. It is at the pre-design stage that a decision is made on the feasibility of the project, a feasibility research is formed, in which not only such basic technical and economic indicators as area, construction volume, length, etc. are of particular importance, but also the composition and cost of individual space-planning and design solutions. So, one and the same object can be erected from monolithic reinforced concrete and bricks, or from pre-fabricated metal structures and multilayer enclosing structures. At the same time, the functional purpose of the object will remain the same, but the cost will change significantly.
In this regard, the relevance of this article lies in the research of methods for determining the cost of various design solutions at the pre-project stage as the basis for successful project implementation in the future. Since the most economically sound solutions identified at an early stage can significantly reduce the costs of the entire project and increase its efficiency.
The purpose of this research is to improve approaches to substantiating the cost of various design solutions at the pre-project stage of the implementation of an investment and construction project.
The authors reviewed the existing methods of substantiating the cost of design solutions for construction projects at the pre-project stage of an investment and construction project and also developed proposals for their improvement: an algorithm for estimating the cost of construction at the early stages of an investment and construction project, taking into account the cost of alternative design solutions.
The implementation of the algorithm became possible thanks to the authors' development of a methodology for creating a data bank on the cost of design solutions, accumulation, analysis and structuring of data on the cost of already implemented residential and civil facilities (administrative buildings with a total area of 1,000 to 20,000 m^2). A factorial analysis of the cost of administrative buildings was also conducted with identifying the causes of deviations in the cost of identical indicators from the average value.
The results obtained can form the basis for the formation of a new database of prices of constructive solutions necessary for calculating the estimated cost at the stage of investment justification. Such data will be able to determine the cost more reliably precisely at the early stages — at the stage of transition from the idea to the development of basic technical solutions that will determine the appearance, manufacturability and cost of construction projects.
Keywords: *cost of design solutions, investment and construction project, pre-design stage, aggregated cost indicators*



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INTRODUCTION

When implementing any investment and construction project (ICP) both the state and private companies are always faced with the task of achieving the greatest efficiency, namely, the construction of a capital construction facility with the necessary capacity, reliability, durability at the optimal cost of construction, ensuring profit from the implementation of the investment project [1, 2]. In this regard, during this study, the work on determining the cost of construction objects was studied and summarized, taking into account the phases of the life cycle of an investment and construction project both in the Russian Federation and abroad[1, 2, 3] [3–6]. One of the key objectives of Strategy for the development of the construction industry and housing and Communal Services of the Russian Federation until 2030 in the direction of improving pricing in construction is to increase the reliability of determining the cost at all stages of the investment cycle, including at the stages of investment planning, design, construction, operation and maintenance, demolition[4].

1 Methodology for the development and application of enlarged construction price standards, as well as the procedure for their approval : Order of the Ministry of Construction of the Russian Federation dated 05.29.2019 No. 314/pr. URL: https://minstroyrf.gov.ru/upload/iblock/959/Metodika-rarabotki-i-primeneniya-ukrupnennykh-normativov-tseny-stroitelstva_-a-takzhe-poryadok-ikh-utverzhdeniya.pdf

2 On approval of the Methodology for determining the estimated cost of Construction, Reconstruction, Capital Repairs, Demolition of Capital Construction facilities, works to preserve cultural heritage objects (Historical and Cultural Monuments) of the Peoples of the Russian Federation on the Territory of the Russian Federation : Order of the Ministry of Construction of the Russian Federation No. 421/pr dated 08.04.2020. URL: https://minstroyrf.gov.ru/upload/iblock/3fb/Metodika-opredeleniya-smetnoy-stoimosti-stroitelstva_rekonstruktsii_-kapitalnogo-remonta_-snosa-obektov-kapitalnogo-stroitelstva_-rabot-po-sokhraneniyu-obektov-kulturnogo-naslediya.pdf

3 On approval of the Procedure for determining the initial (maximum) price of the contract, the price of the contract concluded with the sole supplier (contractor, contractor), the initial price of a unit of goods, work, services during procurement in the field of urban planning (except for territorial planning) and the Methodology for estimating the contract, the subject of which is the construction, reconstruction of capital construction facilities : Order of the Ministry of Construction of the Russian Federation No. 841/pr dated 23.12.2019. URL: https://minstroyrf.gov.ru/upload/iblock/331/Poryadok-opredeleniya-nachalnoi_-_maksimalnoi_-tseny-kontrakta.pdf; https://minstroyrf.gov.ru/upload/iblock/ecf/Metodika-sostavleniya-smety-kontrakta_-predmetom-kotorogo-yavlyayutsya-stroit….pdf

4 Strategy for the development of the construction industry and housing and communal services of the Russian Federation until 2030 with a forecast for the period up to 2035. URL: http://static.government.ru/media/files/AdmXczBBUGfGNM8tz16r7RkQcsgP3LAm.pdf

To do this, both Russian and international companies spend a significant amount of money on optimizing the engineering approach to design, creating variable models that evaluate both the technical side of the project and its economic efficiency. It is noted that currently large investors and customers, engineering companies in Russia and the world have begun to analyze and take actions aimed at organizing the process of choosing optimal solutions in construction projects, starting from the moment of defining the general concept [6–8].

The methods and indicators of determining the cost correlate with the phases of the implementation of the ICP, for them there are uniform clear rules for assessing and controlling the cost [9–17]. So, at the pre-project stage, the estimated or approximate cost of construction is determined on the basis of analogous facilities and enlarged cost indicators, at the design stage, the estimated cost is determined based on current resource prices and (or) specially developed prices with their translation into current prices, and finally, at the stage of concluding contracts, the contract price is calculated, which takes into account actual and forecast inflation indices. In many ways, they are determined depending on the type of financing of the construction object: budget or commercial [9, 12, 16].

One of the most significant from the point of view of estimating the cost of the ICP stages is the stage of pre-project studies. It is at this stage that a decision is made to implement the ICP, its investment attractiveness is calculated, data on the main planned design solutions are considered, which means that the cost is formed, which will later be clarified[5, 6] [18–20].

The difficulty lies in the fact that at the time of substantiating the estimated cost of construction at the early stages in the absence of developed project documentation, the cost is determined approximately: using enlarged construction price standards or data on the cost of analogous facilities. In both cases, mainly previously erected objects with their specific characteristics are taken as a basis, often without detailing the cost for specific solutions. At the same time, the use as analogues of project documentation for facilities whose construction has not been started or completed entails greater risks than when using documentation for facilities put into operation. It is noted that there is no single algorithm for evaluating specific design solutions, including space-planning and structural ones at this stage.

METHODS AND MATERIALS

The methodological basis for writing this paper is the methods of comparison and generalization in the framework of the literature review, as well as a number of studies by the authors in the field of construction economics, cost determination and management, the methodology of the life cycle of investment and construction projects, methods of economic cost modelling[7] [16, 17, 21]. In addition, the paper uses the authors' work in the field of research of the concepts of capitalization and cost of capital construction projects in modern conditions [9, 22, 23].

The works of a number of authors were also reviewed, in which it is noted that the final choice of design solutions is one of the most important stages of architectural and construction design, which is preceded by the stage of the investment plan[2] [10, 12, 14, 15]: determination of the purpose of the investment project, consideration by the customer of several options for the implementation of the project, providing a given project goal, but differing in the composition of the work, their cost, duration, complexity and economic efficiency of the results of the project. It is important that when working out design solutions, all stages of the implementation of an investment and construction project are studied and options for choosing design solutions are evaluated in terms of their impact on the cost and revenue side of the project (economic efficiency). In socially significant projects, economic efficiency is not the only and sufficient condition for the implementation of the project: budgetary and public efficiency are also allocated, which also affects the choice of design solutions[8] [10, 11, 24, 25]. However, a significant limitation for the implementation of the project is its cost, hence such close attention to decisions that directly affect it.

Consideration of various options for the implementation of an investment project at the early stages is carried out based on the initial data available at the time of consideration, and is subject to adjustment at subsequent stages of development. At the same time, when considering options, it is mandatory to take into account a number of factors that affect the feasibility of the investment project, the achievement of the specified parameters and goals, and the period and cost of its operation [10, 13, 26, 27]:

- regional climatic and geotechnical features of construction;
- regional and economic features of the construction region;
- purpose and planned service life of the facility;
- customer requirements for the main technological solutions, production flow chart (for industrial facilities);
- customer requirements for design and space-planning solutions;
- customer requirements for architectural solutions;
- requirements of the current legislation in terms of labor protection, fire safety, industrial safety and compliance with the requirements of technical regulations;
- conditions for the placement of objects, buildings and structures associated with the presence of zones with special conditions for the use of territories.

Thus, the development of all options for the implementation of an investment and construction project is carried out taking into account the listed factors.

As part of the consideration of various options for design solutions, the solutions planned for implementation are analyzed for compliance with the current regulatory requirements, the effectiveness and feasibility of the main (fundamental) considered solutions are assessed, the availability of opportunities for optimization of the decisions made is analyzed, requirements for the preparation of initial data for the design of facilities are formed (Fig. 1). The adopted project decisions must comply with the requirements of legislative acts, regulatory legal acts of the constituent entities of the Russian Federation, standards, set of rules, technical standards, land use and development rules.

The result of a pre-design analysis of an investment and construction project is an assessment of the main advantages and disadvantages of the proposed project options, the proposal of

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6 Register of cost-effective design documentation for reuse. URL: https://fgiscs.minstroyrf.ru/#/

7 State Information System Unified State Register of Conclusions. URL: https://egrz.ru/

8 Official website of the Unified Information System in the field of procurement. URL: https://zakupki.gov.ru/epz/main/public/home.html

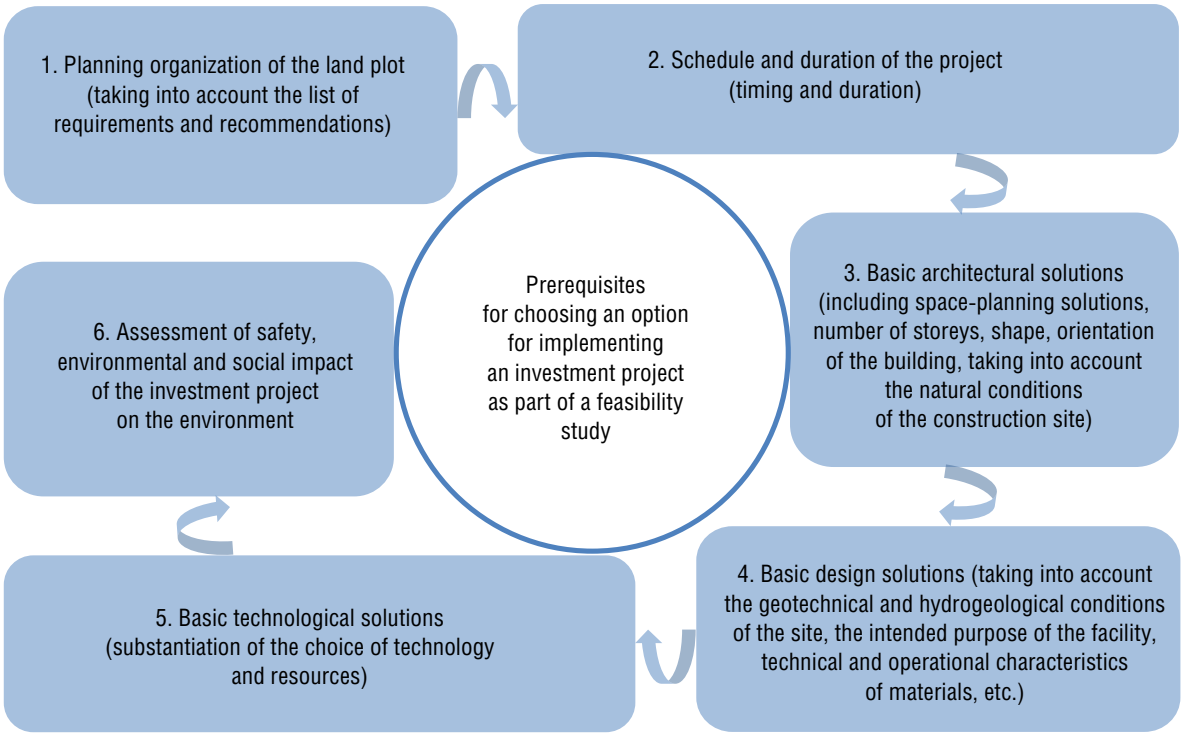


Fig. 1. Prerequisites for choosing an option for the implementation of an investment and construction project as part of a feasibility study

recommendations for choosing an implementation option, recommendations on the preparation of initial data for the design of facilities, as well as the formation of a recommended list of regulatory legal acts necessary for subsequent stages of the project life cycle [12–14, 18].

When developing options for implementing an investment and construction project, state and private companies can obtain the proposed design options from various sources, but these sources of information are imperfect and have a number of specific features (Table 1).

All of the above sources do not form a single information field and have limited use, which determines the need to improve existing methods of forming databases on design solutions and their cost indicators for their subsequent use in cost modelling of projects (elaboration and evaluation of options for the implementation of investment and construction projects). It is also not obvious exactly how and in what sequence the data from these sources should be taken into account.

In terms of cost formation, consideration of various options for the implementation of the project at the early stages is carried out based on the initial data available at the time of consideration, and is subject to adjustment at subsequent stages of development. The difficulty lies in the fact that at the initial stages there is no clear data as such on design solutions and their cost, hence the complexity of a detailed calculation of cost elements.

So, it is natural to determine the value using enlarged cost indicators. Thus, when financing the construction of an object from the state budget, consolidated indicators of the cost of construction (construction price standards CPS) are used[9, 10, 11]. However, the nomenclature of indicator's collections is rather limited[10, 11, 12]. At the same time, the collections do not allow replacing certain constructive solutions as part of their cost, on the one hand. On the other hand, in most indicators, it is possible to adjust only the cost of foundations, equipment and design and survey work. In this regard, in the analysis of design options, in the absence or inapplicability of the corresponding consolidated indicators of the cost of construction, data on the cost of analog objects and their design solutions are used. The selection of an analog object is also a difficult task, since there is no single database of sources of the cost of analog objects, regularly updated and available for work, as evidenced by the data given in Table 1.

Analysis of existing sources of information on the cost of construction and the cost of design solutions at the pre-project stage showed:

1. Currently, there is no unified database on actually implemented investment and construction projects and the list of capital construction objects as part of such projects, which allows an automated search for an object according to the main specified characteristics, including the main performance indicators and cost.

2. Existing data sources have a number of limitations that complicate the search and comparison of capital construction projects, which in some cases does not allow using the experience gained in the development of design solutions for such projects.

9 Town-planning Code of the Russian Federation dated 12.29.2004 No. 190-FZ. URL: http://www.consultant.ru/document/cons_doc_LAW_51040/

10 Official website of the Ministry of Housing and Communal Services of the Russian Federation, section "Pricing". URL: https://www.minstroyrf.ru/trades/gradostroitelnaya-deyatelnost-i-arhitektura/14/

11 Official website of the State Information System of Pricing in Construction. URL: https://fgiscs.minstroyrf.ru/#/

12 Cost-effective reuse project documentation, information about which, as of October 1, 2021, is included in the unified state register of expert opinions on project documentation for capital construction projects, is recognized as standard project documentation

Table 1. Analysis of data sources on capital construction facilities and their assessment

Data source	Advantages	Disadvantages
Register of cost-effective design documentation for reuse[6, 12]	• significant amount of information; • presence of estimate documentation as part of the project documentation; • reliability of information	• lack of data on production facilities; • lack of data on unique, technically complex and especially dangerous capital construction projects; • complexity of the analysis of posted information; • lack of design and estimate documentation for some objects
GIS USRR (Unified State Register of Reports)[7]	• reliability of information; • possibility of obtaining information about the results of non-state examination of project documentation and (or) the results of engineering surveys	• lack of open access to design (including estimate) documentation of objects, information about which is contained in the USRR
Databases of design organizations containing data on objects, the design and working documentation of which was developed by these organizations	• accumulated information on previously designed facilities (for organizations that have existed for a long time); • reliability of information	• lack of information about the cost of the completed construction of the object
Databases of individual large companies, formed on the basis of data on completed or planned investment projects of new construction, reconstruction, overhaul	• accumulated information on previously designed and implemented objects (for organizations that have existed for a long time); • availability of information on the actual cost of the completed construction of the facility; • presence in a number of companies of consolidated unit prices for certain types and sets of work	• lack of information about other objects or alternative options implemented in other companies
Open sources (books, media, internet)	• availability of data on the cost of large investment projects	• unreliability of information

3. Available sources of data on investment and construction projects contain information about the capital construction object at the stage of "design documentation". There is no data on changes made at the stage of "working documentation" and information about the facility at the stage of commissioning. Thus, there is no statistics on changes in the cost of implementing an investment and construction project at different stages of its life cycle.

4. Due to the lack of systematized data, comparison of both capital construction objects in general and individual design solutions and their cost is possible only within companies or organizations that have accumulated experience in the design and/or implementation of similar objects.

RESULTS

The results of the preliminary assessment of the cost of implementing the ICP serve as the basis for making a decision on the need, technical feasibility, commercial, economic and social feasibility of investments in construction. For a preliminary assessment of the cost of implementing an investment project, it is recommended to make a decomposition of the main decisions and factors affecting the cost indicators of the project. It is important to take into account that all decisions should be considered comprehensively, taking into account the stages of the life cycle of the ICP.

A comparative analysis of the cost of projects can be carried out both in an enlarged way, when considering implementation options that differ significantly from each other, and in detail, by comparing the cost of individual solutions, for example, in terms of foundations, the cost of enclosing structures, solutions for interior decoration, etc.

During the initial consideration of options, as a rule, it is done "from top to bottom", by assessing from the total cost of the project to the analysis of the cost of certain types of work and expenses. As the cost is detailed, the types of expenses can be aggregated:

1. Necessary for any option for the implementation of an investment project (costs of engineering surveys, development of design and working documentation, payment for land and land tax during the construction period, work on site preparation, archaeological surveys (if necessary), cleaning the area from explosive objects (if necessary), compensation payments for the demolition of green plantings, payment for the state examination of project documentation and the results of engineering surveys (in cases stipulated by the legislation of the Russian Federation), costs of temporary buildings and structures, costs of work in the winter, etc.

2. Expenses, the cost of which varies depending on the implementation option of the investment project (costs of construction and installation work, purchase of process and utility equipment, commissioning, costs of connection (utility connection) to engineering networks, etc.

3. Expenses that, in some options for project implementation, are not necessary (costs of relocation of certain types of construction equipment, costs of a rotational work method, individual solutions to protect construction from various geological and hydrogeological processes (mudflows, landslides, flooding and other hydrogeological processes).

For the most reliable determination of the cost of design solutions at the pre-project stage, the authors have developed an algorithm for justifying the cost of the ICP implementation option. The basis of the algorithm was the decomposition of the stages of evaluation and analysis of the cost as an object as a whole, and the main design decisions and factors affecting the cost indicators of the project.

The first stage of the algorithm is based on a preliminary factor analysis of the cost of implementing the ICP (Fig. 2).

1.1. Analysis of regional climatic, geotechnical, regional economic features of the construction region

1.2. Analysis of the list of buildings and structures included in the ICP

1.3. Analysis of preliminary performance indicators (capacity of facilities, length of external engineering networks, area of improvement and landscaping)

1.4. Analysis of the technical characteristics of space-planning and structural solutions (structural diagram of a building, type of foundations, wall material, type of floors, roofs, etc.) (if any)

1.5. Analysis of the main technological equipment for the enlarged nomenclature

Fig. 2. Stage 1. Analysis of factors influencing the cost of an investment and construction project at the pre-project stage

2.1. Comparative analysis of the cost of the options for project implementation	1) determination of the cost structure of each variant of the project implementation with the determination of the specific weight (in percentage) of each consolidated cost element; 2) comparison of the structure and specific weight of cost elements of all considered options; 3) factor analysis of changes in the cost of elements in comparison with other considered options; 4) if errors in the calculations are identified that significantly affect the cost of an option, an analysis of changes in the final cost of this option is made, taking into account the correction of the identified inconsistencies
2.2. Comparative analysis of the cost with similar objects (including international objects), implemented in comparable conditions, as well as with their individual cost indicators	1) selection of objects similar in functionality, design capacity, natural and other conditions of the territory on which construction is planned; 2) analysis of the similarity of the performance indicators of the object under consideration and the analogue object in terms of the functional purpose of the investment project, design capacity, composition of buildings and structures, construction region, main performance indicators; 3) analysis of the estimated regulatory framework and the current price level adopted to determine the current cost of analogue projects, bringing the cost indicators of all analogue projects to the price level of the object under consideration; 4) decomposition of the cost of an analogue project; 5) determination of the boundaries of the range of cost of analog projects for the adopted unit of measurement; 6) comparison of the value of the cost indicator and similar indicators of analog projects. Analysis of the reasons for deviations from the average cost; 7) in case of significant deviations of the value of the object under consideration from the cost of analogous projects, an analysis is carried out in terms of the possibility of cost optimization, indicating the identified factors affecting the cost of the project
2.3. Analysis of methods for determining the cost of the project	1) analysis of the analog method and the method based on aggregated cost indicators; 2) consideration of pricing methods: base-index, resource and resource-index methods

Fig. 3. Stage 2. Analysis of the cost of options for the ICP implementation

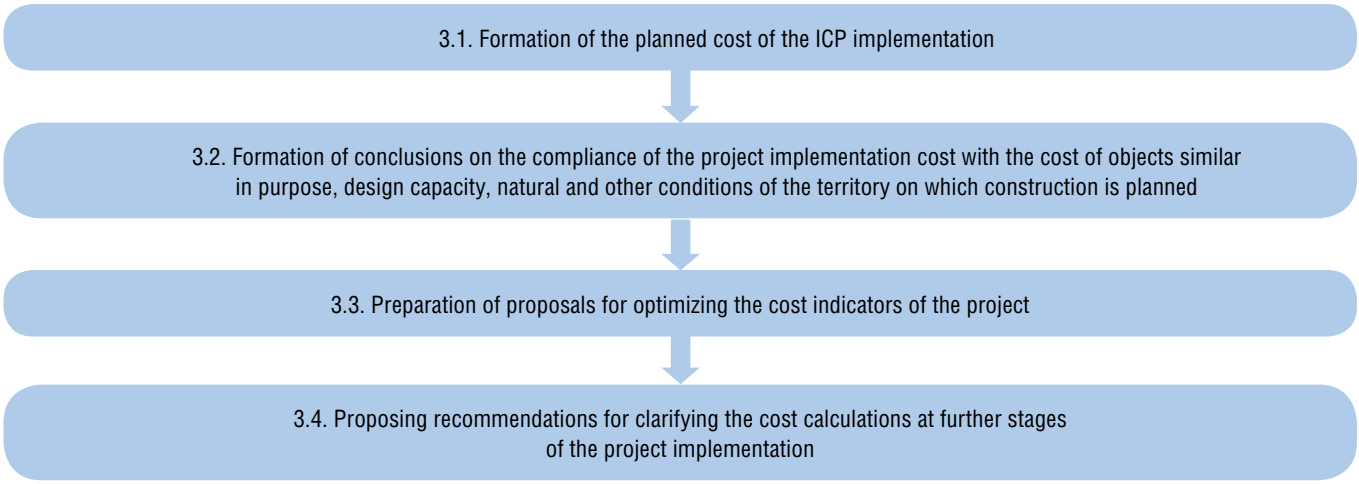


Fig. 4. Stage 3. Estimation of the cost of ICP

The second stage of the algorithm directly describes the analysis of the cost of options for the implementation of ICP (Fig. 3). It includes working with similar objects (including international objects) implemented in comparable conditions, as well as with their individual cost indicators, a comparative analysis of the design decisions adopted in the project, as well as methods of their calculation.

The third stage is the final cost assessment at the pre-project stage, including the preparation of proposals for optimizing the cost indicators of the project, as well as proposals for recommendations on clarifying cost calculations at further stages of the project (Fig. 4).

The algorithm proposed by the authors for the cost estimation of project solutions at the pre-project stage is the basis of a system for analyzing the cost of project implementation options. This algorithm can be actively used in the customer's organizations when evaluating various project implementation options, including for the purpose of preparing a reasonable design assignment.

The application of the algorithm in the practice of construction companies is difficult due to the lack of statistical data on the cost of various solutions for previously implemented projects. However, at the moment there is no unified methodology for analyzing the cost of design solutions for the formation of such a data bank. In this regard, one of the authors' proposals is to return to the idea of creating at the state level a base of price standards for constructive solutions that will allow forming an idea of the cost of specific structural elements and work complexes at the pre-project stage. Also, within the framework of using the prices of constructive solutions, it is possible to finalize the indicators of the CPS (construction price standards) in terms of allocating the share of costs for the technical characteristics of constructive solutions and types of work taken into account in the indicator. In this case, it would be possible to replace the cost of a constructive solution in the CPS based on the standards of the price of constructive solutions.

At the same time, in the absence of officially approved collections of the standards of the price of constructive solutions in order to create a data bank on the cost of project solutions, the authors propose their own methodology and forms of documents for analyzing the cost of project solutions based on already approved project documentation.

Next, we will give an example of the implementation of the methodology of systematization, processing and accumulation of data on the cost of already realized objects and the cost of their design solutions. The data for the example are taken from the project documentation of open sources[6, 8], as well as data from development projects. Further, the analysis of the cost of design solutions for housing and civil objects will be considered: administrative buildings with a total area of 1,000 to 20,000 m^2. For

Table 2. The cost indicators of the construction of administrative buildings

Number	Capital construction object name	At the price level for 2022 (thousan.rubles, VAT included)							
		Cost of 1 m^2	CIW	Equipment	Other	Cost of 1 m^3	CIW	Equipment	Other
Average indicator for objects									
1	Administrative buildings up to 1,000 m^2	**110.1**	86.8	10.1	13.2	**22.9**	18.2	2.2	2.5
2	Administrative buildings from 1,000 to 5,000 m^2	**99.7**	69.5	19.9	10.3	**23.6**	16.4	4.8	2.4
3	Administrative buildings from 5,000 to 20,000 m^2	**111.5**	74.5	27.9	9.1	**25.2**	16.8	6.3	2.1
4	Administrative buildings more than 20,000 m^2	**178.6**	139.0	27.6	12.0	**25.1**	19.5	3.9	1.7

each type of the considered objects, the weighted average indicator of the unit cost of the measurement unit was determined (1 m² of total area, 1 m³ of construction volume, 1 place (if any) at the stage of "design documentation").

The average value of deviations between the minimum and maximum indicators of objects of the same functional purpose was about 40 % (Table 2).

In terms of the cost of administrative buildings, the consolidated, object and local estimates developed at the stage of "design documentation" were analyzed.

The comparative analysis was performed according to the following algorithm:

1. Selection of design documentation (including the section "Estimates for building capital construction objects") for capital construction projects that are identical in functionality.

2. Grouping of objects by capacity characteristics (total area "from" and "to", number of places "from" and "to", etc.) and thus dividing objects of the same functional purpose into groups.

3. Analysis of objects within the formed group according to the technical characteristics of design solutions.

4. Analysis of the structure of the estimated cost on the basis of summary estimate calculations among objects within the same group, aggregated identification of cost items that differ significantly among the same type of objects. For comparison, the total cost was reduced to a single specific indicator — the cost of 1 m² of the total area.

5. Identification of deviations in the values of the specific indicator, as well as the difference in the ratio of costs in the technological structure of capital investments (construction and installation work, equipment, other costs).

6. Additional analysis of objects with significant differences in cost items. In order to identify the reasons for the deviation of a significant difference in the volume of work, the cost of types of work and expenses were reduced to an indicator per unit of measurement (m² of total area, m³ of construction volume, 1 km of utility networks, 100 m² of landscaping area, etc.) in form based on the structure of the consolidated estimate calculation, given in Table 3.

As a result of the analysis, identical indicators were identified that significantly differ in cost.

Within the framework of factor analysis, the reasons for deviations in the cost of identical indicators of capital construction objects were analyzed, subject to consideration for the reasons for deviations from the average. Among the solutions that significantly increase the cost of construction, we can highlight:

1. Design solutions related to the selection of the construction site:

- the presence of hazardous natural processes requiring engineering protection of the territory. At the same time, the most

Table 3. Form of a table for analyzing the cost indicators of a capital construction object

Number	Cost structure	Design documentation code; Object name			Consolidated estimate calculation				
		Object name			Estimated cost, thousand rubles				Total estimated cost, thousand rubles
					Construction works	Installation works	Equipment, furniture and fittings	Other costs	
		Measurement units	Quantity	Price per unit, thousand roubles, at the current price level without VAT					
		Place							
		m² of total area							
		m³ of construction volume							
1	Chapter 1. Preparation of the construction site				-	-	-	-	-
	including:								
1.1	Layout of the main axes of buildings and structures								-
1.2	Payment for land upon withdrawal (redemption) of a land plot for construction, as well as payment of land tax (lease) during the construction period								-
	….								-
	and so on in accordance with the chapters of the consolidated estimate								

common solutions were the construction of retaining walls from monolithic reinforced concrete and cementation of soils. The solutions for the construction of the land cofferdam are also expensive. Design solutions related to the seismicity of the construction site and the possibility of karsts (installation of damper joints in the building, installation of sleeves in the foundation for cementation of possible karst cavities under the foundation of the building) did not have a significant impact on the total cost;

- design solutions involving the use of imported materials that require significant transport costs.

2. Design solutions related to the type of foundations. The choice of the type of foundation is largely affected by the results of engineering surveys. However, in a number of cases, when considering objects, excessive design solutions were revealed — an increase in the thickness of the foundation slab, an excess thickness of the basement walls.

3. Design solutions related to the construction of buildings with complex shapes.

4. Design solutions related to the use of non-serial (non-standard) building products and structures, for example, non-serial products made of precast concrete, non-standard metal structures, etc.

5. Design solutions involving the use of expensive building and finishing materials, for example, aluminum stained-glass mullion-transom systems, porcelain stoneware, decorative wall panels, etc.

6. The use of expensive process and utility equipment exceeding the necessary requirements in terms of its technical characteristics.

DISCUSSION AND CONCLUSION

If we level out legal and permissive issues in the implementation of an investment and construction project, then we can see that the choice of imperfect or unsuitable design solutions for a particular case has the greatest impact on the timing of the implementation of projects and on their cost in terms of achieving a given level of quality.

When assessing the cost of design solutions for each variant of the implementation of an investment and construction project, in most cases, the need for a detailed assessment of the cost of individual solutions is revealed, even at the pre-project stage. Construction companies can apply the algorithm within the framework of project implementation in order to accelerate the cost determination process at the early stages of design, as well as increase the reliability of cost determination. The algorithm will also be relevant for government agencies to verify projects as part of the technological and price audit of projects to include them in state-funded budget programs. The algorithm is based on an up-to-date data bank on the cost of design solutions, which determines the reliability of cost forecasting. Processing and systematization of this kind of information can be carried out by both large commercial developers and other stakeholders, for example, Centers for Pricing in construction, state and non-state expertise bodies, engineering companies, etc. In general, such a detailed study of the cost of individual solutions at the pre-project stage will increase the accuracy of cost calculations and in some cases save budget funds.

At the moment, calculations within the framework of the methodology are carried out only for administrative buildings, which is a significant drawback. However, it seems promising to further accumulate and systematize data on various implemented projects with the allocation of initial data on various types of objects implemented in various conditions and regions of construction according to the forms of documents developed by the authors.

The results obtained can form the basis for the formation of a new database of prices of constructive solutions necessary for calculating the estimated cost at the stage of the project concept. Such data will be able to determine the cost more reasonably precisely at the early stages – at the stage of transition from the idea to the development of basic technical solutions that will determine the appearance, manufacturability and cost of our facilities, as well as be in demand at the early stages of object modelling using information modelling technologies.

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Совершенствование методов определения стоимости проектных решений на ранних этапах реализации инвестиционно-строительных проектов

Перечень основных решений по реализации инвестиционно-строительного проекта описывается и утверждается в составе проектной документации, однако выбор и обоснование этих решений производятся заказчиком и инвестором уже на предпроектном этапе. Именно на предпроектном этапе принимается решение о целесообразности проекта, формируется технико-экономическое обоснование, в котором особое значение имеют не только такие основные технико-экономические показатели, как площадь, строительный объем, протяженность и т.п., но и состав и стоимость отдельных принятых объемно-планировочных и конструктивных решений. Так, один и тот же объект может быть возведен из монолитного железобетона и кирпича, а может — из быстровозводимых металлоконструкций и многослойных ограждающих конструкций. При этом функциональное назначение объекта останется прежним, но стоимость значительно изменится.

В связи с этим актуальность данной статьи заключается в исследовании методов определения стоимости различных вариантов проектных решений на предпроектном этапе как основы успешной реализации проекта в будущем, так как наиболее экономически обоснованные варианты решений, выявленные уже на ранней стадии, могут существенно снизить затраты всего проекта и повысить его эффективность.

Целью исследования является совершенствование подходов к обоснованию стоимости различных проектных решений на предпроектной стадии реализации инвестиционно-строительного проекта.

Авторами рассмотрены существующие методы обоснования стоимости строительства на предпроектном этапе инвестиционно-строительного проекта, а также разработаны предложения по их совершенствованию: составлен алгоритм оценки стоимости строительства на ранних этапах инвестиционно-строительного проекта с учетом стоимости альтернативных проектных решений.

Реализация авторами алгоритма оценки стоимости строительства на ранних этапах инвестиционно-строительного проекта стала возможной благодаря разработке методики создания банка данных о стоимости проектных решений, накопления, анализа и структурирования данных о стоимости уже реализованных объектов жилищно-гражданского назначения (административных зданий общей площадью от 1000 до 20 000 м^2). Также проведен факторный анализ стоимости административных зданий с выявлением причин отклонений стоимости идентичных показателей от среднего значения.

Полученные результаты могут лечь в основу формирования новой базы данных цен конструктивных решений, необходимых при расчете предполагаемой стоимости на этапе обоснования инвестиций. Такие данные смогут позволить определять стоимость более достоверно именно на ранних этапах — на этапе перехода от задумки к разработке основных технических решений, которые будут определять облик, технологичность и стоимость строительных объектов.

Ключевые слова: *стоимость проектных решений, инвестиционно-строительный проект, предпроектный этап, укрупненные показатели стоимости*

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For citation: Chernova P.A., Bovsunovskaya M.P. Improvement of methods for determining the cost of design solutions at early stages of investment and construction projects realization. *Real Estate: Economics, Management*. 2023; 4:21-30.

Для цитирования: *Чернова П.А., Бовсуновская М.П.* Improvement of methods for determining the cost of design solutions at early stages of investment and construction projects realization // Недвижимость: экономика, управление. 2023. № 4. С. 21–30.

UDC 339.13

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Conceptual model of pre–project marketing research and its impact on the quality of investment and construction project

The scientific paper is devoted to the issues of pre-project marketing research and its impact on the quality of investment and construction project (ICP) and the quality of finished construction products. In modern conditions of economic crisis and increased competition of goods and services marketing plays a special role in all spheres of activity, including the construction industry. The authors note that not all organizations in their practical activities pay due attention to pre-project marketing research. In order to develop the methods of pre-project marketing research already used in practice by marketing departments and to form new unique approaches in organizations, the authors have developed a conceptual model of pre-project marketing research. The author's conceptual model is aimed at improving the effectiveness of pre-project marketing research — obtaining information that meets the established requirements. The article presents these requirements, in particular, the requirement for completeness of information is considered in the most detail, negative consequences of information insufficiency and excess for the project and its participants are outlined, methods of ensuring completeness of information are proposed. Attention is paid to the high value of marketing information obtained at the pre-project stage of a project for decision-making at subsequent stages of ICP and for building a marketing strategy within an organization's project activities. Based on the analysis, the authors provide a logical justification for the positive impact of pre-project marketing research on the quality of individual processes and activities within the life cycle of ICP and, ultimately, on the consumer and production quality of finished construction products.
Keywords: *marketing research, pre-project stage, model of pre-project marketing research, information, quality of investment and construction project, quality of construction products*

The quality of the final construction product — a real estate object — is determined by the synergistic effect of the quality of each individual process of an investment and construction project (ICP). Within the framework of the concept of life cycle management of a real estate object, the initial stage is the pre-project stage, which includes measures and processes for initiating, conceptualizing and evaluating the viability of the project. A preliminary idea and promising decisions about the architectural and expressive and spatial-planning appearance, location, financial model and other parameters of the future real estate object are established based on a comprehensive analysis of trends and forecasts of the investment and construction industry, its individual components and other sectors and economic factors associated with it [1]. An effective mechanism for searching and collecting data at the early stages of a project is pre-project marketing research [2, 3].

In modern realities, marketing research is carried out in large holdings of investment and construction profiles and development companies, where there are separate departments and marketing departments in organizational structures [4, 5]. Such real estate market participants conduct their profile activities mainly in the rapidly developing regions of the Russian Federation – Moscow and the Moscow region, St. Petersburg, Yekaterinburg, Tyumen, Kazan, Krasnodar. In addition, according to the authors' observations, over the past 5 years, the number of individual consulting organizations specializing in marketing activities in the field of investment and construction complex has increased significantly on the market.

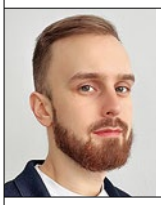
It is obvious that each department responsible for the marketing activities of the organization has its own developed methodologies for pre-project marketing research to achieve the set goals of the projects. These methodologies are mainly based on the basic principles of marketing theory and practice, taking into account the specifics of real estate as a commodity [6–9]. The analysis showed that at the moment there are no normative methodological and recommendation documents regulating the conduct of pre-project marketing research in modern economic conditions.

At the same time, the prevailing number of developers and construction companies on the market do not possess any marketing research mechanisms at all, due to the saving of financial and time resources, the lack of competent professional personnel and a low level of project management. Under these circumstances, organizations rely on the inertia of the real estate market, that is, on a condition in which, regardless of location and conceptual solutions, the real estate object will still be in demand by the consumer.

Summarizing the above, today there are two significant problems in the framework of pre-project marketing:

1. Imperfection of existing marketing research mechanisms, characterized by the incompleteness of the range of objects and depth of research, as well as the inconsistency of marketing analysis tools with modern and promising economic conditions.

2. Partial or complete absence of marketing research activities at the pre-project stage of the ICP for most developers and construction companies, especially regional ones.



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The conceptual model of pre-project marketing research proposed by the authors is based on principles similar to marketing research of consumer markets (Fig. 1) [10–12]. The first stage, preparatory, consists in setting the problem, goals and objectives of marketing research for an investment and construction project and determining research methods. The second, research stage involves the direct conduct of pre-project marketing research. Within the framework of this stage, three independent but interrelated levels are distinguished: the macro level is aimed at a comprehensive study of individual spheres of society that most affect the project or the activities of the organization as a whole; at the meso level, the current situation and vectors of progress of the real estate market, its objects, subjects and various kinds of relationships between them are analyzed; the study of the micro level is focused on the examination of internal corporate activities and their results. In the final third stage, the evaluation and processing of the data obtained, the formation of conclusions is carried out, after which the marketing information is used for various purposes in subsequent project phases.

The developed conceptual model will solve the following tasks:

1. To become a reference point for the creation of a corporate principled model of marketing research in organizations of the investment and construction sector, which previously did not have such a model.

2. To become an additional base for improving the existing mechanisms of pre-project marketing research.

The imperative result of marketing research activities is information. The value level of the final information characterizes the productivity of research activities and determines tactical behavior in the long-term management of project solutions [13, 14]. In order to systematize the information obtained in the course of marketing research, and target and rational application in the economic activities of the organization of the investment and construction complex, the information must meet a set of requirements [15]. In the context of pre-project marketing research for construction products, the main requirements include reliability (the ability of information to reflect actual facts), relevance (compliance of information with a certain time period), objectivity (absence of dependence on the human factor).

The authors note that a special requirement for marketing information in order to consistently achieve the planned quality of the project stages is the completeness of information, which is characterized by a minimum set of data sufficient for comprehensive analysis and decision-making. However, in practice, determining the sufficiency of information for its further use within the framework of the ICP may cause difficulties. This is mainly due to the argument that both a lack of information and an excess of it can have a negative effect on the processes that are based on the results of marketing research. The consequences of such an effect through the prism of deficit and surplus can manifest themselves in different ways (Table).

The analysis shows that the primary factor of the possible phenomenon of information deficit or surplus is subjective, since the data processing cycle for marketing research is controlled by a person. In order to avoid the occurrence of adverse consequences for the participants of the ICP, it is proposed that specialists and structural units responsible for marketing apply the following methods or combinations of them in practice:

1. Principle of the “golden mean” is the search and establishment of a set of information determined by the optimality and moderation of data.

2. Principle of reasonable sufficiency (similar to the Concept of information security of the Federal Tax Service) is the search, processing and archiving of a set of information, with further work with which the costs, risk and amount of possible damage are considered acceptable within the framework of the project and the economic activities of the research organization as a whole.

3. Principle of potentially redundant information (David Hoffman, 1952) — analysis and exclusion of unnecessary and repetitive data that do not carry additional information benefits.

4. Method of data imputation (Maurice Bartlett 1937; Bradley Efron 1977) — filling in missing data with other statistical values.

The result of pre-project marketing research — systematized marketing information that meets certain requirements — forms the basis for future processes and operations within the project. First of all, the data of marketing information predetermine specific steps in the development of a business plan, architectural and urban appearance, at all stages of architectural and construction design, during the construction and operation of a real estate object. In addition, the information obtained from the results of pre-project marketing research serves as key input data for the development of an ICP marketing strategy, which involves the formation and management of a dynamic model for maintaining the competitive advantage of the organization and fulfilling the goals of the project throughout its life cycle. Acting as a satellite in the systematic movement from stage to stage within the framework of the ICP, marketing information is the most important means of reducing project risks and achieving efficiency at individual stages, contributes to improving consumer (the product meets the requirements and desires of consumers)

The impact of information deficit and surplus on the ICP

Information obtained during pre-project marketing research	
The deficit effect	The surplus effect
The developer (investor) does not have the most complete preliminary idea of the project and finished construction products	Potential excess of actual financial and labor costs over the originally planned values
Low level of input data for the development of a marketing strategy for the project	Possible loss of time and a shift in the timing of subsequent stages of the project
Poor quality of decision-making in individual project processes under conditions of uncertainty	Poor quality of decision-making in individual project processes in the context of a disordered information flow

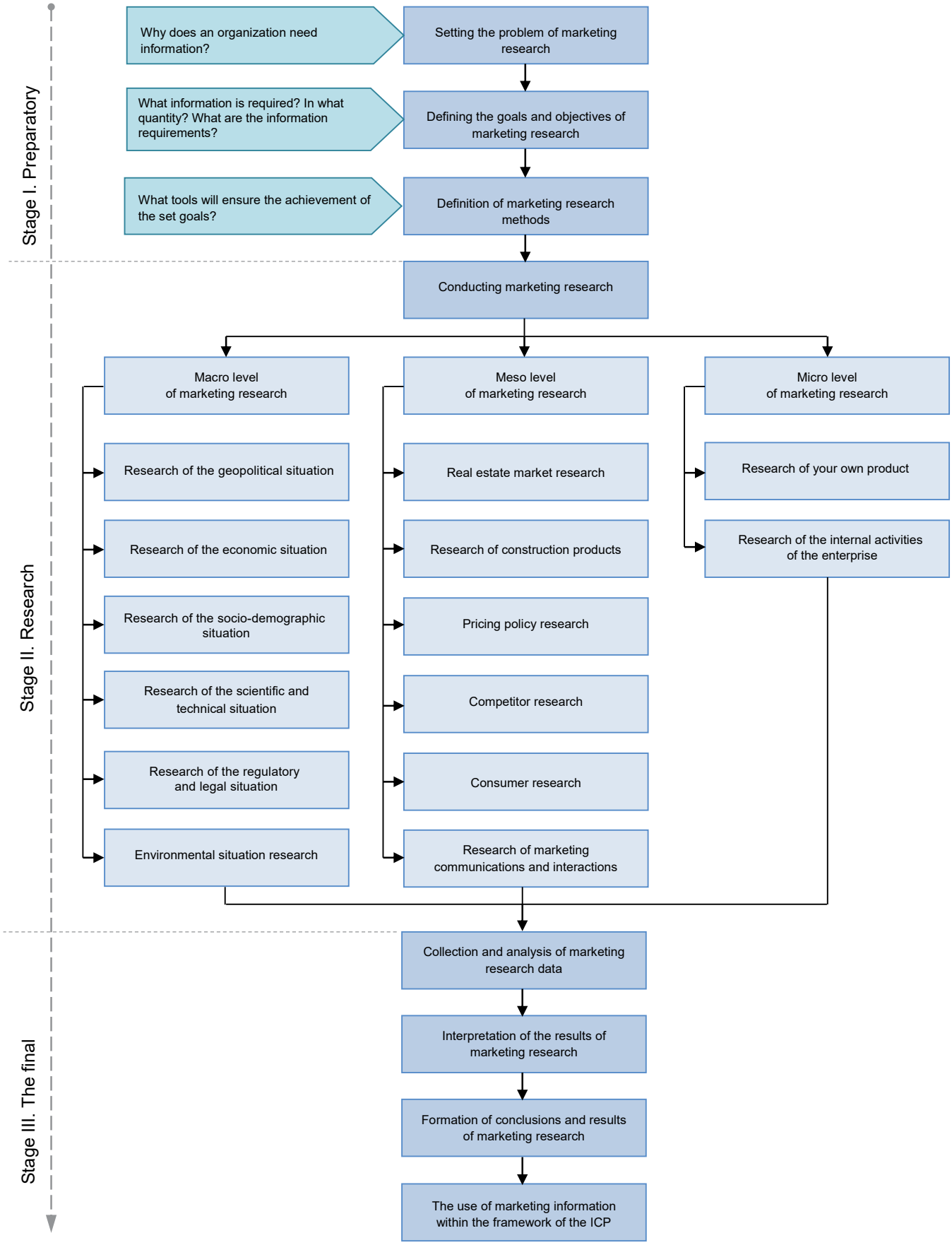


Fig. 1. Conceptual model of pre-project marketing research

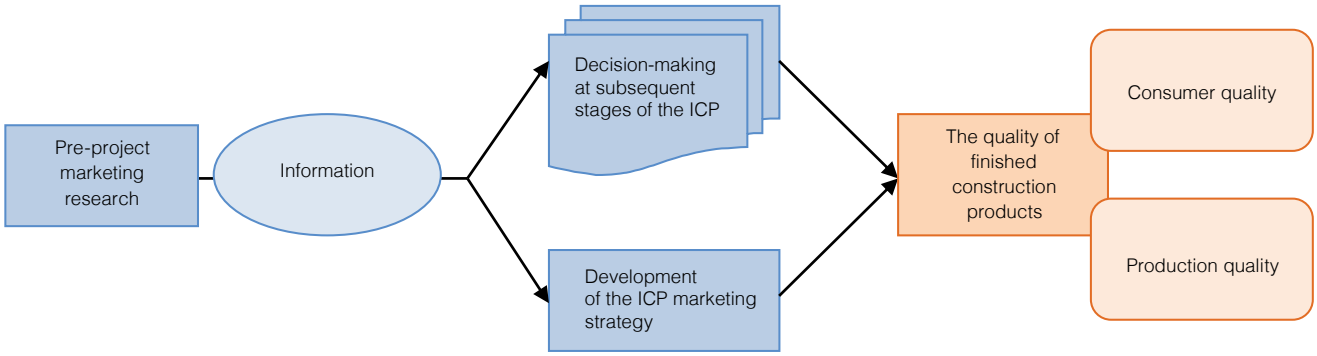


Fig. 2. The impact of pre-project marketing research on the quality of finished construction products

and production (the product meets the requirements of regulations, standards and regulations) quality of finished construction products.

Thus, the influence of pre-project marketing research and its results, as a generalization of the meaning of the proposed conceptual model, on the quality of the ICP and finished construction products is expressed by a correlated relationship. That is, the marketing research event, being the starting point of a logical chain, through direct sequential dependence with other events — the key processes of the project, affects the quality of finished construction products (Fig. 2).

The basis of this logical view is the basic principle of scientific research — the search for new knowledge, obtaining new information in order to establish facts and implement ideas. The conceptual model proposed by the authors, as a form of pre-project marketing research within the framework of the ICP, together with the established information requirements, makes it possible to provide the organization of the investment and construction complex with the most meaningful, relevant and objective information fund. As a result of systematic pre-project marketing, the stable and competitive activity of the organization is ensured, its progressive development in the real estate market with the ability to freely respond to factors of the internal and external environment and maintain high consumer loyalty.

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Концептуальная модель предпроектных маркетинговых исследований и ее влияние на качество инвестиционно-строительного проекта

Научная статья посвящена вопросам проведения предпроектных маркетинговых исследований и их влиянию на качество инвестиционно-строительного проекта (ИСП) и качество готовой строительной продукции. В современных условиях кризисных явлений экономики и повышенной конкуренции товаров и услуг маркетинг играет особую роль во всех сферах деятельности, в том числе и строительной отрасли. Авторами отмечается, что не все организации в своей практической деятельности уделяют должное внимание предпроектным маркетинговым исследованиям. Для развития уже используемых на практике маркетинговыми подразделениями методик предпроектных исследований и формирования новых уникальных подходов у организаций авторами была разработана концептуальная модель предпроектных

маркетинговых исследований. Авторская концептуальная модель направлена на повышение результативности предпроектных маркетинговых исследований — получение информации, отвечающей установленным требованиям. В статье представлены данные требования, в частности, наиболее подробно рассмотрено требование к полноте информации, обозначены негативные последствия информационной недостаточности и излишка для проекта и его участников, предложены методы обеспечения полноты информации. Уделяется внимание высокой ценности маркетинговой информации, полученной на предпроектном этапе проекта, для принятия решений на последующих стадиях ИСП и выстраивания маркетинговой стратегии в рамках проектной деятельности организации. На основании анализа авторами приводится логическое обоснование оказания положительного влияния предпроектных маркетинговых исследований на качество отдельных процессов и мероприятий в рамках жизненного цикла ИСП и, в конечном счете, на потребительское и производственное качество готовой строительной продукции.

Ключевые слова: *маркетинговые исследования, предпроектная стадия, модель предпроектных маркетинговых исследований, информация, качество инвестиционно-строительного проекта, качество строительной продукции*

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For citation: Abdalov R.E., Kulakov K.Yu. Conceptual model of pre-project marketing research and its impact on the quality of investment and construction project. *Real Estate: Economics, Management*. 2023; 4:31-35.

Для цитирования: *Абдалов Р.Е., Кулаков К.Ю.* Conceptual model of pre-project marketing research and its impact on the quality of investment and construction project // Недвижимость: экономика, управление. 2023. № 4. С. 31–35.

UDC 332.8:004.9

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Design and digital transformation of the Moscow urban management system

The article deals with the goals, objectives, features, principles and factors of the implementation of the infrastructure project for the creation of the Centre of Management of the Urban Economy Complex (CMUC) as a center of competence and application of communication and digital technologies. The problematic aspects of the functioning of the housing and communal services (HCS) as the most important socio-economic system of the city economy and one of the largest in the world are revealed. The strategic directions of digital transformation of the management system of the housing and communal services of Moscow are formulated. The main organizational and methodological approaches to the formation of the structure of the project of the Centre of Management of the Urban Economy Complex are identified. The principles of forming an automated information system (CMUC) are substantiated in order to ensure the interoperability of departmental information systems of enterprises and municipal organizations. A problem-oriented interoperability model has been developed, the main components of which are the software and hardware complex of the control center of the CMUC, data storage, including indicators of the state of housing and communal services objects, ranking them according to a set of criteria. It has been proved that the aggregation of big data allows you to make current and strategic management decisions online and to prevent possible incidents on the basis of complex analytics, to level their consequences. The materials proposed in the article on the digital transformation of the Moscow urban management system include the formation of the process of management decision-making by the leadership of the CMUC based on the transformation of existing functions and the development of new analytical tasks, monitoring data on the identification and implementation of work to eliminate defects, damage, emergencies by city engineering services situations. Transformation of the housing and communal services management system based on digital solutions can be carried out by a stage-by-stage transition to intermediate models corresponding to different levels of digitalization.

Keywords: *digitalization, housing and communal services, control center, interoperability, decision making*



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INTRODUCTION

Moscow is one of the most promising and dynamically developing megacities in the world with modern and high-quality urban infrastructure. A comfortable environment and high-quality maintenance of urban areas significantly influence the development of the economy of a modern city. Housing and communal services of Moscow, as the most important socio-economic life-support system of the city's economy include the operation and repair of apartment buildings, roads, landscaping and landscaping facilities, power supply systems, gas supply, heat supply, water supply, sewerage and drainage, and other facilities. The Moscow housing and communal services sector at the present stage is actively involved in the digitalization of the economy: at the level of business processes of a technological and managerial nature, at the level of interaction with consumers and as a participant in the public services sector, responsible for the quality of provision of utility services. At the same time, the need for digitalization of housing and communal services is associated with the introduction of modern technologies and increasing the requirements of service consumers for the quality of housing and communal services.

However, today the positive influence of factors increasing the digitalization of housing and communal services faces many organizational and economic restrictions associated with rising costs caused by the need to transform the infrastructure of "smart technologies" and attract investments. Housing and communal services, like other areas that require digitalization, have significant professional and production limitations. In addition to known industry limitations, these shortcomings are aggravated by the traditional competencies of employed workers [1].

The quality of competencies for the development of IT technologies and their use in the daily circulation of providing quality services to the population can be increased through the implementation of a model of integration interaction between enterprises and organizations in the housing and communal services sector. The presence of a significant number of departmental information systems in a metropolis does not make it possible to effectively use the information integration of city services economy in the digitalization of the housing and communal services sector. Coordinated scientific, methodological, organizational and economic methods for incorporating digital technologies into management decision-making in the housing and communal services sector also require development [2].

CONTENT

In order to ensure the sustainable functioning of the housing and communal infrastructure of Moscow, for the first time in the Russian Federation, the largest infrastructure investment and construction project was implemented to create a Centre of Management of the Urban Economy Complex (CMUC). The implementation of the CMUC is aimed at the digital transformation of the Moscow urban management system.

Over the 1.5 years of operation of the CMUC, a regulated and coordinated interaction of all city services and authorities has been built within the common information field in the CMUC. This made it

possible to increase the speed and efficiency of response to changes occurring in the city. The Control Center houses representatives of all engineering, technological, organizational and management divisions of Urban Economy Complex and government authorities. They supervise and monitor the functioning of systems and objects in real time. Data on accidents, incidents and critical events are automatically displayed on the video wall screen in the Situation Room. As a result, employees interact with each other as much as possible, quickly processing incoming information. All industry events are ranked according to the degree of criticality in the context of objects and departments, the scale of the incident is determined and a decision is made to eliminate problem situations [3–6].

RESULTS

When forming the automated information system of the Centre of Management of the Urban Economy Complex (CMUC), in order to ensure the interoperability of departmental information systems of enterprises and organizations of the urban economy, a problem-oriented model of interoperability of departmental information systems of enterprises and organizations of the urban housing and communal services was created with the creation of a unified intellectual center for strategic forecasting development of housing and communal infrastructure and ensuring the sustainable and reliable functioning of the city's life support system[1] [7, 8].

The Moscow Service 112 is located on the basis of the CMUC, which has increased the efficiency of its interaction with other services.

All parts of the capital's housing and communal services work process have been formed into a single information chain, provide a detailed assessment of the quality of work of all organizations in the sector and ensure the comfort and safety of residents of the capital. The Center employs almost 200 analysts from the State Budgetary Institution "MAC", who 24/7 conduct operational monitoring of the state of the complex's facilities, with an average of about 23.5 thousand events, and forecast the development of the situation [3, 9, 10].

CONCLUSION

The design and digital transformation of the Moscow urban management system includes the creation of a system of information and forecast support for management decision-making by the management of the Urban Economy Complex based on the transformation of existing functions and the development of new analytical tasks, including:

- monitoring data on the identification and implementation of work to eliminate defects, damage, emergency situations, technical condition of utility networks and public utility facilities, residential areas by city engineering services;
- ensuring interaction of the monitoring system with administrative and housing and communal city systems and databases, generating statistical data based on the information received;
- creating models that predict the operating modes of utility networks and production and technological infrastructure during the operational period of their life cycle;
- organizing participants in information exchange, their interaction with city resource-providing organizations in Moscow and federal-level services to coordinate activities for the sustainable and safe operation of urban management systems;
- improving the system for analyzing information and developing regulatory documents, forecasting the revision and updating of standards [11–14].

The transformation of the housing and communal services management system based on digital solutions requires a phased transition of intermediate states, which include the service economy, the network Internet economy, and the Internet economy of artificial intelligence. For its implementation, the following methodological approaches are proposed with the definition of conditions and models for transforming the housing and communal services management system: selection of intermediate models corresponding to different levels of digitalization; structuring digital components corresponding to a certain intermediate digitalization model; algorithm for determining the stages of transformation of management processes in the housing and communal services system. The transformation of the housing and communal services management system can be interpreted as a controlled process, the purpose of which is to synchronize the strategies of digitalization and development of the housing and communal services sector [12, 13].

Scientific and practical recommendations for modelling regional information and digital management centers for housing and communal services using the example of the infrastructure project of the Centre of Management of the Urban Economy Complex (CMUC) of Moscow, as the basis for the digital transformation of the management system and mechanisms for testing technologies for new digital solutions in the housing and communal services system, can be used as best practices for replication by other regions and large cities with a fairly high digitalization index.

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Проектно-цифровая трансформация системы управления городским хозяйством Москвы

В статье рассматриваются цели, задачи, особенности, принципы и факторы реализации инфраструктурного проекта создания Центра управления комплекса городского хозяйства (ЦУ КГХ), как центра компетенций и применения коммуникативно-цифровых технологий. Раскрыты проблемные стороны функционирования жилищно-коммунального хозяйства (ЖКХ), как важнейшей социально-экономической системы экономики одного из крупнейших в мире городов. Сформулированы стратегические направления цифровой трансформации системы управления жилищно-коммунального городского хозяйства Москвы. Определены основные организационно-методические подходы к формированию структуры проекта Центра управления комплекса городского хозяйства. Обоснованы принципы формирования автоматизированной информационной системы (ЦУ КГХ) с целью обеспечения интероперабельности ведомственных информационных систем предприятий и организаций городского хозяйства. Разработана проблемно-ориентированная модель интероперабельности, основными компонентами которой являются программно-аппаратный комплекс ЦУ КГХ, хранилище данных, включающее показатели состояния объектов ЖКХ, ранжирование их по набору критериев. Доказано, что агрегация больших данных позволяет принимать текущие и стратегические управленческие решения в режиме онлайн и предупреждать на основе комплексной аналитики возможные инциденты, нивелировать их последствия. Предлагаемые в статье материалы по цифровой трансформации системы управления городским хозяйством Москвы включают формирование процесса принятия управленческих решений руководством Комплекса городского хозяйства на основе трансформации имеющихся функций и развития новых аналитически задач, мониторинга данных о выявлении и выполнении работ по устранению инженерными службами города дефектов, повреждений, аварийных ситуаций. Трансформация системы управления ЖКХ на основе цифровых решений может осуществляться поэтапным переходом к промежуточным моделям, соответствующим различным уровням цифровизации.

Ключевые слова: цифровизация, ЖКХ, центр управления, интероперабельность, принятие решений

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For citation: Balashov E.B. Design and digital transformation of the Moscow urban management system. *Real Estate: Economics, Management*. 2023; 4:36-38.

Для цитирования: *Балашов Е.Б.* Design and digital transformation of the Moscow urban management system // Недвижимость: экономика, управление. 2023. № 4. С. 36–38.

UDC 69.059:504.05

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Systematization of factors influencing the formation of carbon footprint value during the life cycle of capital construction objects

The purpose of the paper is a system representation of the factors influencing the formation of the carbon footprint value formed during the life cycle of capital construction objects. The main methods of work are analysis and systematization. The results of the work are presented in the form of a matrix of factors. The use of this matrix makes it possible to make more accurate calculations of the carbon footprint value formed during the life cycle of capital construction objects, as well as to develop databases for the calculation of the identified factors.
Keywords: *carbon footprint, capital construction objects, factors, systematization*

INTRODUCTION

Reducing the carbon footprint (hereinafter referred to as the "CF") formed during the life cycle (hereinafter referred to as the "LC") of capital construction facilities (hereinafter referred to as the "CCF") remains a relevant topic of scientific research. According to the Intergovernmental Panel on Climate Change (hereinafter: IPCC), the built environment generates 40 % of annual global CO_2 emissions. Of these total emissions, construction work account for 27 % per annum, while building and infrastructure materials and structures (embodied carbon, causing indirect emissions) are responsible for an additional 13 % per annum. We are currently seeing the largest wave of construction in human history, with about 2.6 trillion feet (240 billion m^2) of new building construction expected to add to the global building stock from 2020 to 2060. In 2040, approximately 2/3 of the global building stock will be buildings that exist today. Without widespread decarbonization around the world, these buildings will continue to emit CO_2 (direct or indirect) and the Paris Agreement target of 1.5 °C will not be reached[1].

Despite the fact that the issue of decarbonization is relevant, both in Russia and abroad, to date, in domestic practice, a methodological apparatus has not been fully developed that takes into account all the factors in the formation of the CF, with software and relevant information databases, which makes it possible to produce calculations of the value of the CF of the CCF, depending on the various factors that form it and on the stages of the life cycle at which they are located. However, identifying and taking into account all the factors influencing the formation of the CF of buildings will improve calculation methods, create databases for information systems and services for calculating the CF, develop systems for low-carbon certification of construction projects and solve a number of essential government tasks.

MAIN PART

Factors that make it possible to evaluate the design of a future building from the standpoint of low-carbon design solutions used (construction resources, space-planning solutions) were identified in the study [1]. However, the above factors do not take into account the carbon footprint of energy-saving engineering equipment used in construction projects (water supply, heating, and air conditioning systems), the use of energy-saving windows with low-emission coatings and other active and passive energy saving methods indicated in [2] and others. Accounting for these factors is extremely important, since there is a directly proportional relationship between energy saving and carbon footprint [3]. It has been proved that engineering systems and technologies are the determining factor at the stage of building operation [4]. The carbon footprint of the operation of engineering systems is primarily determined by their energy consumption

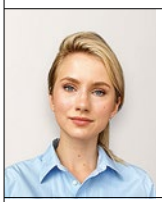
The longest stage LC of CCF is the operational stage, the energy costs for its provision are the most significant. Around 43 % of energy resources are spent on heating, 31 % on electricity supply [5]. According to a UNEP worldwide report, energy demand in buildings has increased by about 4 % compared to 2020 (to 135 EJ), while CO_2 emissions from building operation have reached an all-time high of about 10 gigaton of CO_2, which is 5 % more than in 2020, and 2 % more than the previous peak recorded in 2019[2]. Multi-apartment and individual residential buildings, public and business buildings form 80 % of the total area of buildings in Russia and consume 927 million Gcal of thermal energy for heating needs per year, which is more than 75 % of the total consumption of thermal energy in the country. The production of thermal energy for these buildings results in annual greenhouse gas emissions of 252 million tons of CO_2-eq. is 12 % of

1 Why the built environment? URL: https://architecture2030.org/why-the-building-sector/ (accessed: 08.15.2023).

2 United Nations Environment Programme. Global Status Report for Buildings and Construction: Towards a Zero-emission, Efficient and Resilient Buildings and Construction Sector. Nairobi, 2022.



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the total greenhouse gas emissions in the country[3]. Therefore, the stage of operation LC of the CCF contains a number of important factors that form its carbon footprint during the life cycle.

The analysis of scientific works of domestic authors showed that the determination the value of the CF of CCF has the following methodological foundations:

1. Dividing the total value of the CF into direct and indirect emissions.

2. Formation the CF during the life cycle of the CCF.

3. Directly proportional dependence the value of the CF on the applied solutions for energy saving and reducing the resource intensity of the life cycle of the CCF.

4. Use of information modeling technologies [6–8].

An analysis of the works of foreign authors showed that there are four most important criteria that determine buildings with zero carbon emissions: decarbonization, electrification, efficiency and digitalization [9, 10]. The methodological basis for determining the CF during the LC is the life cycle analysis (LCA — life cycle assessment), used in various modifications [11–14].

The factors affecting the size of the carbon footprint of buildings during the life cycle are heterogeneous, therefore, for their systematic presentation and further work on the formation of an information system, the authors systematized and compiled on the matrix of factors (Figure). This form of presentation allows to evaluate the factors by types of influence on the formation of the carbon footprint (matrix rows) and distribute them according to the stages of the life cycle of the CCF according to ISO 22263 in conjunction with the stages of forming the CCF information model according to CP 333.1325800.2020 (matrix columns).

The factors affecting the carbon footprint value of buildings during the life cycle are heterogeneous, therefore, for their systematic presentation and further work on the formation of an information

<table>
<tr><td>Stages of the life cycle of CCF according to ISO 22263</td><td>Preliminary steps</td><td>Pre-construction stages</td><td>Construction stages</td><td colspan="3">Stages after completion of construction</td></tr>
<tr><td rowspan="2">Stages of formation of an engineering model of the CCF according to SP 333.1325800.2020 Model type</td><td>Engineering survey</td><td>Architectural and construction design (design)</td><td>Construction</td><td>Exploitation</td><td>Reconstruction, capital repair</td><td>Demolition and disposal (liquidation)</td></tr>
<tr><td>Engineering digital terrain model (EDTM)</td><td>EDTM, DIMCS CCF — design model</td><td>EDTM, DIMCS CCF — building model executive model</td><td>EDTM, DIMCS CCF — Operating model</td><td>EDTM, DIMCS CCF — building model executive model</td><td>EDTM, DIMCS CCF — Demolition model and dismantling</td></tr>
<tr><td rowspan="2">Direct Impact Factors</td><td rowspan="2">–</td><td rowspan="2">–</td><td>The mass of greenhouse gases released during the generation of electrical or thermal energy to ensure the operation of the construction site</td><td>The mass of greenhouse gases released during the generation of electrical or thermal energy for heating and (or) cooling of the facility, as well as gas supply</td><td>The mass of greenhouse gases released during the generation of electrical or thermal energy to ensure the operation of repair and construction work</td><td rowspan="2">The greenhouse gases emitted during the use of construction machinery and mechanisms with electric drive and diesel engines in the process of dismantling and disposal</td></tr>
<tr><td>The mass of greenhouse gases emitted during the use of construction machinery and mechanisms with electric drive and diesel engines</td><td>The mass of greenhouse gases emitted from materials used in engineering systems during operation</td><td>The greenhouse gases emitted during transportation, disposal and processing of construction waste and waste after repairs</td></tr>
<tr><td>Factors of indirect influence</td><td>The mass of greenhouse gases emitted during the work on the project (energy costs for the operation of the project office and data centers, consulting, transport emissions associated with the selection of a land plot)</td><td>The mass of greenhouse gases emitted during the work on the project (energy consumption for the work of the project office and data centers)</td><td>The mass of greenhouse gases emitted during the extraction, production and transportation of materials, products, structures and human resources</td><td>–</td><td colspan="2">The mass of greenhouse gases emitted during the use of construction machinery and mechanisms with electric drive and diesel engines during repairs</td></tr>
</table>

Matrix of factors influencing the formation about CF of the CCF throughout the LC

3 Increasing energy efficiency and reducing the carbon footprint of buildings. Governing legislation and incentives. URL: https://www.abok.ru/for_spec/articles.php?nid=8440

system, the authors systematized and compiled on the matrix of factors (Figure). This form of presentation allows you to evaluate the factors by types of influence on the formation of the carbon footprint (matrix rows) and distribute them according to the stages of the life cycle of the CCF according to ISO 22263 in conjunction with the stages of forming the CCF information model according to CP 333.1325800.2020 (matrix columns).

CONCLUSIONS

The factors indicated in the matrix that influence the formation about CF of the CCF during the life cycle are expressed as the mass of greenhouse gases emitted directly or indirectly at various stages LC of the CCF. Working with this matrix will make it possible to create advising databases on the amount of greenhouse gases with reference to one or another factor for carrying out multivariate calculations on the value of the CF at different stages of its life cycle or throughout the life cycle as a whole.

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Систематизация факторов, влияющих на формирование величины углеродного следа в течение жизненного цикла объектов капитального строительства

Целью статьи является системное представление факторов, виляющих на формирование величины углеродного следа, формирующегося в течение жизненного цикла объектов капитального строительства. Проведен анализ ряда работ отечественных и зарубежных ученых, выявлены общие методологические основы расчета величины углеродного следа объектов капитального строительства. Результаты работы представлены в виде матрицы факторов, влияющих на формирование углеродного следа объектов капитального строительства в зависимости от этапов жизненного цикла и этапов формирования информационной модели объекта капитального строительства. Факторы сгруппированы по способу влияния на формирование углеродного следа: прямое и косвенное. Использование данной матрицы позволяет производить более точные расчеты величины углеродного следа, формирующегося в течение жизненного цикла объектов капитального строительства, а также разрабатывать базы данных для расчета выявленных факторов.

Ключевые слова: углеродный след, объекты капитального строительства, факторы, систематизация

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For citation: Oparina L.A., Obukhova Y.D. Systematization of factors influencing the formation of carbon footprint value during the life cycle of capital construction objects. *Real Estate: Economics, Management*. 2023; 4:39-42.

Для цитирования: *Опарина Л.А., Обухова Ю.Д.* Systematization of factors influencing the formation of carbon footprint value during the life cycle of capital construction objects // Недвижимость: экономика, управление. 2023. № 4. С. 39–42.



Москва. Церковь Антипия на Колымажном дворе. Рисунок, тушь перо

UDC 69:004.9

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Enhancing construction control possibilities with the implementation of information modelling technologies for multifunctional real estate objects

Enhancing construction control possibilities with the implementation of information modelling technologies (BIM) is a method of ensuring the organizational and technological reliability of creating multifunctional real estate objects as a tool to increase the effectiveness of this type of commercial construction. Construction control is one of the effective methods of ensuring the organizational and technological reliability of the creation of capital construction facilities, the use of modern technologies can significantly increase their efficiency.
To date, there are still a huge number of questions and difficulties that designers, builders, regulatory authorities and other participants in this area face every day. Large construction companies have already started testing and implementing new technologies.
Every year, information modelling technologies in the Russian Federation are increasingly used at all stages of the life cycle of objects.
BIM technologies are now quite common in design, a little less at the construction stage, and very slightly at the stage of operation of buildings and structures. There are Russian developers who create new software for the needs of modern realities, which helps to reduce the time for routine processes, save and verify information, and bring it to all recipients as quickly and without loss as possible[1].
This paper discusses some of the similar technologies that are already being used at the construction and construction control stage in a common data environment (CDE). This allows you to receive data at the right time, and in the right form, without spending a lot of time on all sorts of corrections, which become more costly the later they occur.
At the design stage, if the designer does not receive special requirements from the customer, he has the right to perform the task assigned to him in any way convenient to him. If, at the initial stage of planning the construction of any new or reconstruction of an existing facility, the customer will form a package of requirements not only for the interim results of the entire investment and construction project, but also requirements for further work results (construction and operation)[2], this will allow to clearly build a strategy for all processes at an early stage, select modern technologies that can reduce many costs, and especially financial and time costs.
Keywords: *construction control, BIM, information, technology, quality*



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INTRODUCTION

Organizational and technological reliability (OTR) is the ability of accepted managerial, organizational, design, and technological decisions to implement a construction project on time and with proper quality. Organizational and technological reliability consists of two components: technological reliability and organizational reliability [1].

Technological reliability of construction is a property of the accepted technology of work, selected design solutions, materials and structures used to prevent or minimize defects in construction work leading to an increase in the cost of construction and an increase in time.

Organizational reliability is the ability to organize construction production in such a way as to exclude violations of construction indicators, and in case of any deviations, their prompt elimination and functioning of the system as a whole would be ensured, which ultimately will not exceed the established estimated cost and the directive construction period. One of the tools to ensure an OTR is the use of information modelling technology (BIM).

Construction control is one of the effective methods of ensuring the organizational and technological reliability of the creation of capital construction facilities [2].

According to the regulatory documentation, construction control is carried out during the construction and reconstruction of capital construction facilities in order to verify the compliance of the work performed with design documentation, technical regulations, engineering survey results, requirements established on the date of issuance of the urban development plan of the land plot submitted for obtaining a construction permit, as well as the permitted use of the land plot and restrictions established in accordance with the land and other legislation of the Russian Federation [3].

In the Russian Federation, the rules for the formation and maintenance of an information model of a capital construction facility are regulated by Decree of the Government of the Russian Federation No. 1431, dated September 15, 2020. According to this Federal Law [4], an information model is formed at 5 stages:

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2 On the establishment of cases in which the developer, technical customer, person providing or preparing the justification for investments, and (or) the person responsible for the operation of the capital construction facility ensures the formation and maintenance of an information model of the capital construction facility : Decree of the Government of the Russian Federation No. 331 dated March 5, 2021 (with amendments and as amended on: December 20, 2022). (rus.).

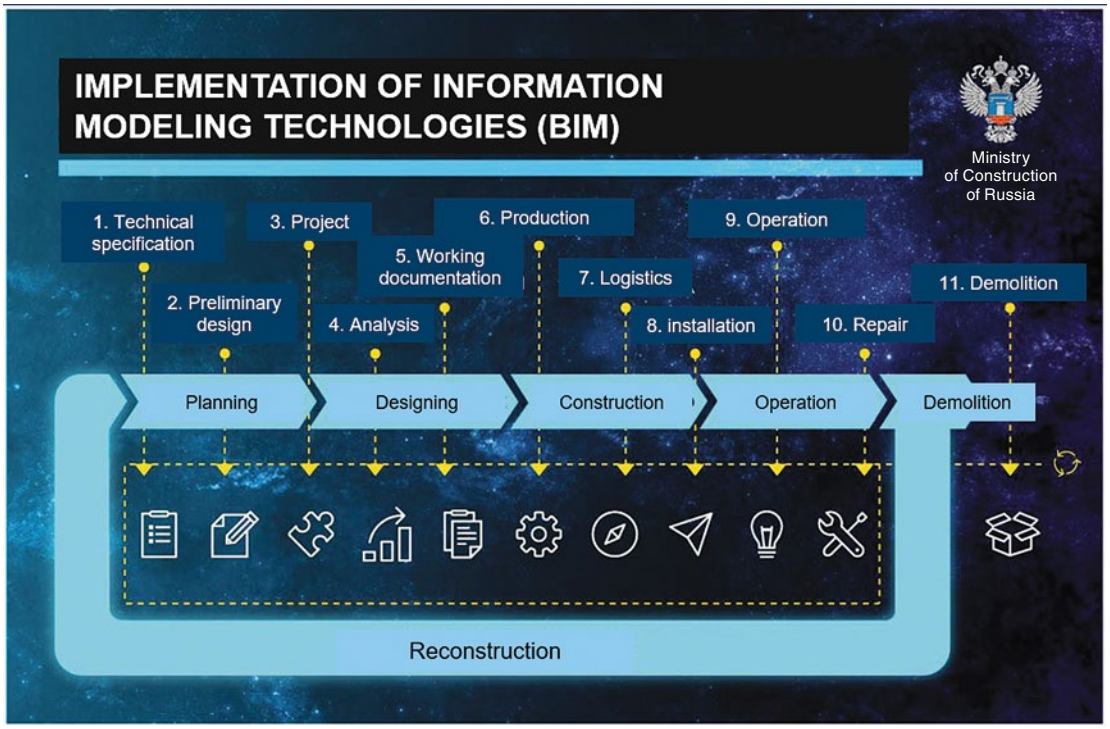


Fig. 1. The life cycle of the construction object

- engineering surveys;
- architectural and construction design;
- construction;
- operation;
- demolition.

In this paper, we will consider the way BIM technology is applied at the stage of the life cycles of a construction object [5], and the opportunities that construction quality control provides using information modelling in the BIM system (Fig. 1).

The information BIM model at the stage of issuing Working Documentation (WD), in the production of works, makes it possible to work with the project for all construction participants, such as:

- developer;
- technical customer;
- construction control of the Technical Customer;
- auditors of working documentation;
- general Contractor;
- author's supervision.

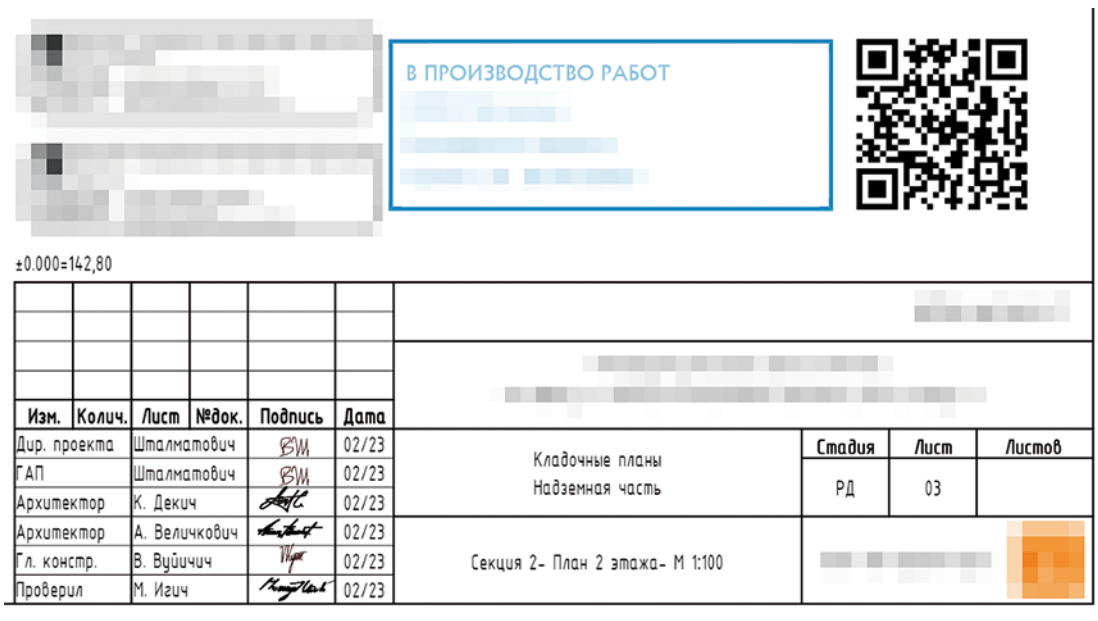


Fig. 2. An example of an issued WD section for the production of works

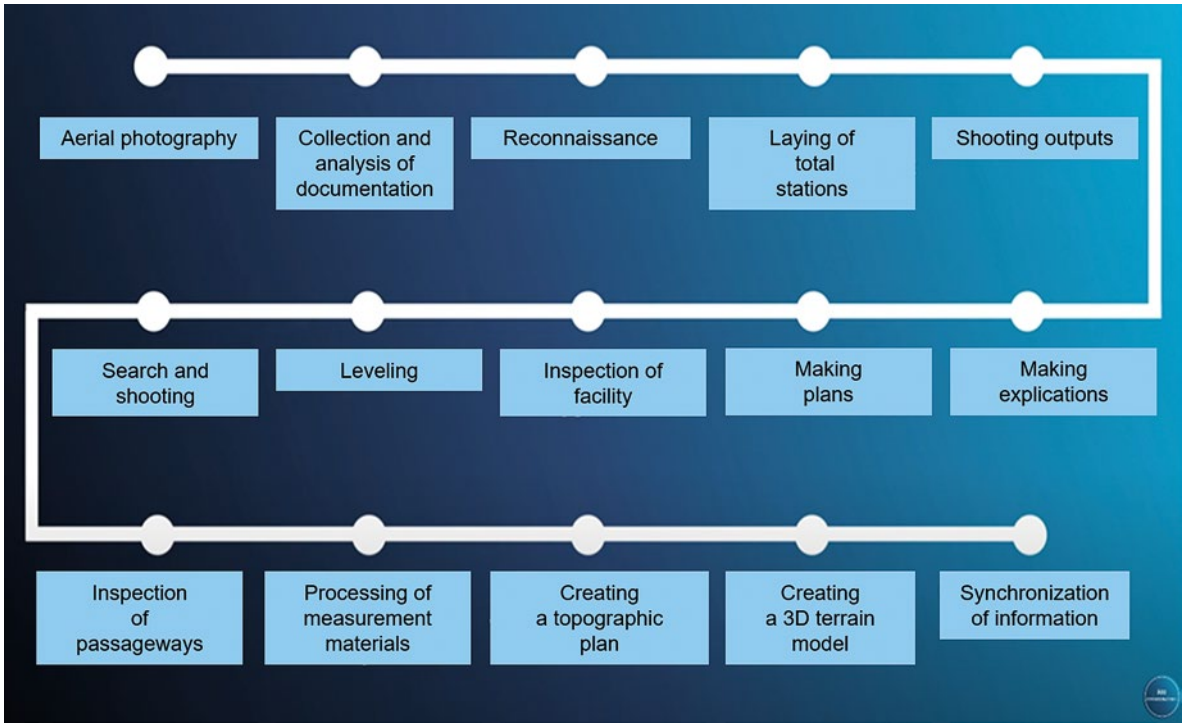


Fig. 3. Sequence of information technology implementation processes using aerial photography

The interaction of all participants in the construction is carried out: by working with the model and issuing WD from it to the production of works (by means of an electronic signature, with the assignment of a unique QR code to each document); using CDE [6]; with the help of which the audit procedure of Working documentation is optimized (it becomes possible to perform work simultaneously for a whole group of audit and reconciliation specialists "P" and "WD" in one section) (Fig. 2).

The introduction of CDE technology in construction made it possible to access up-to-date Working Documentation using a mobile device during construction and installation works (CIW) and Construction control. Using a QR code allows you to quickly determine the status of the documentation.

With the introduction of information technology into the work of Construction control, it became possible to track CIW processes for the entire construction period by using high-resolution photographs with 360° viewing and subsequent preservation (Fig. 3).

It became possible for the Construction Control to issue digital comments indicating the exact location of the identified defect (section, floor, room and structure), a description of the violation, photo fixation and indication of persons responsible for eliminating defects (Fig. 4), this allows you to promptly inform all participants about the violations identified by sending comments from the place of the detected violation, thereby significantly reducing the response time to Contractors' comments [7]. These comments can be exported according to previously set parameters (object, construction stage, section, floor, date of issue of the credit, date of elimination of the comment) to a single register.

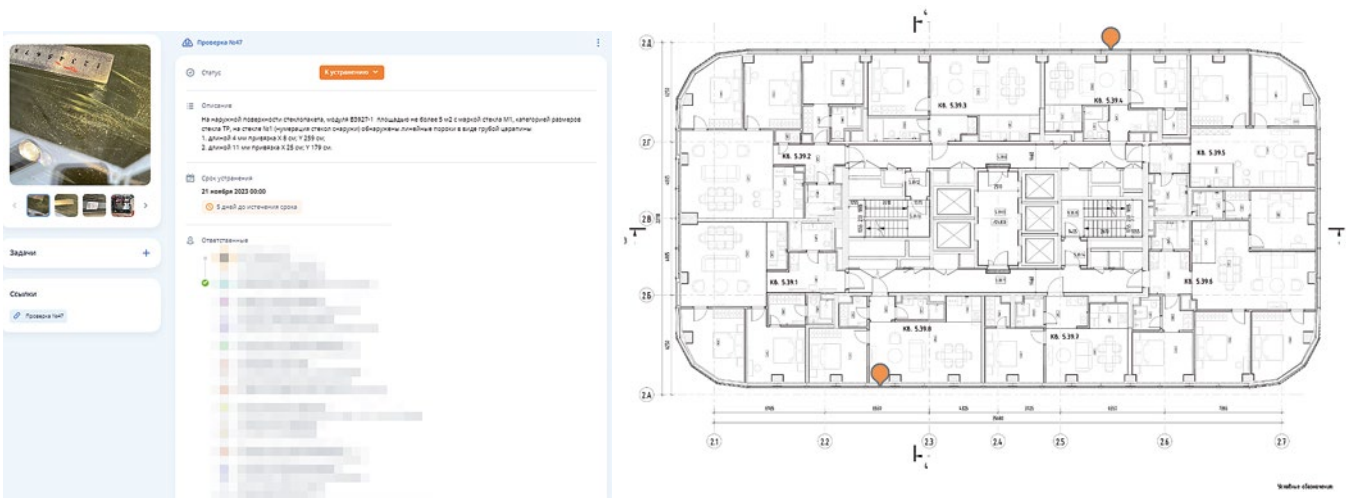


Fig. 4. Example of issuing comments by the Construction Control

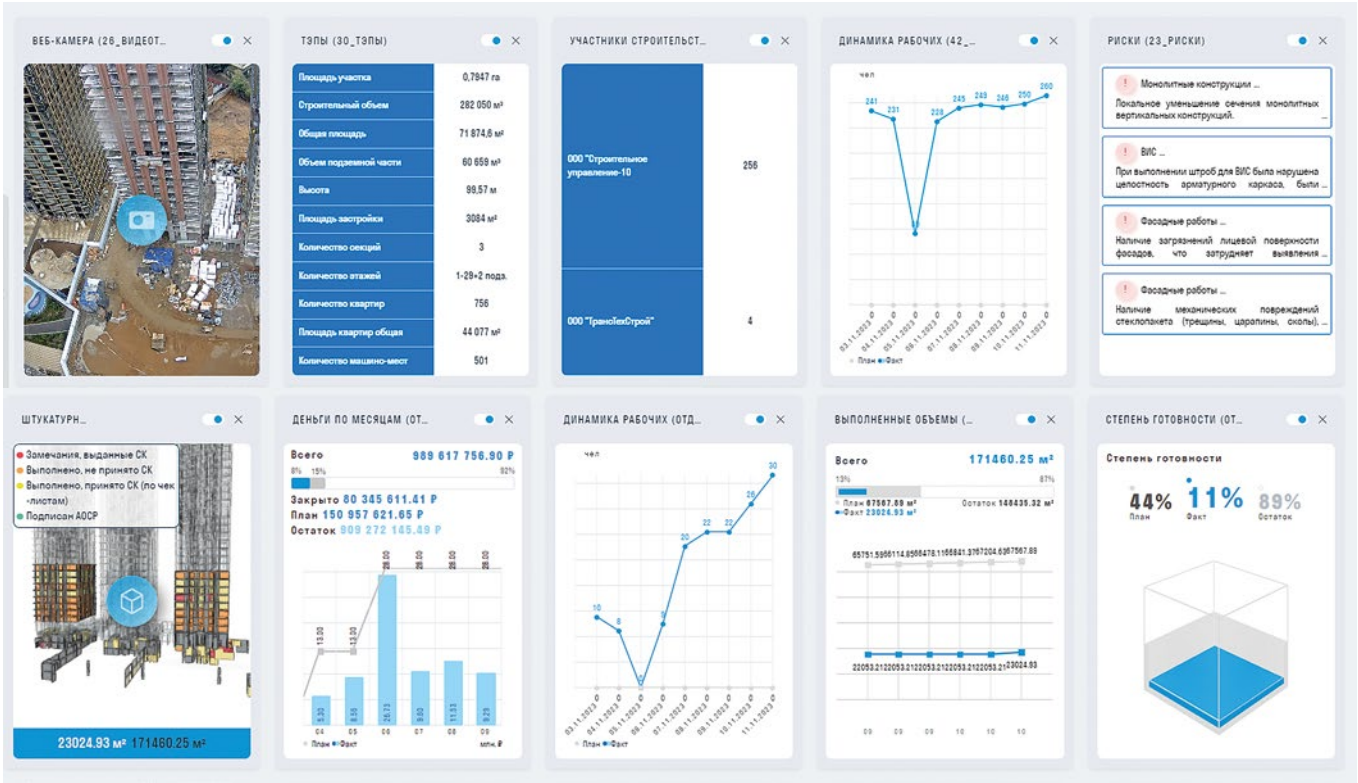


Fig. 5. Example of a card for an object under construction

In order to carry out timely construction work and carry out further construction control, it is necessary to update the current state of the facility and track the progress of construction at each stage and intermediate stages. This gives in terms of the effectiveness of construction control:

- Understanding the actual position of building elements and communications, and deviations from their design position;
- Understanding the amount of work performed.

The technology of an unmanned aerial vehicle (UAV) using 3D scanners is actively used in the work of Construction control, which makes it possible to quickly, accurately and fully confirm the completed volumes at various stages of construction[3]. This 3D scan is subsequently used to automatically build an executive digital information model (DIM).

To structure the information received about the progress of construction processes, services are actively used that allow structuring the information received into short and accessible information cards of the object, to which all project participants have access (Fig. 5) [8]. This information allows to fully reflect the current state of the object, according to such parameters as:

- technical and economic indicators;
- the number of specialists involved;
- project risks;
- the project implementation period in visual diagrams;
- an executive BIM model [9];
- control of made payments (to the General Contractor/to contractors);
- the volume of planned / actually completed work (divided by type);
- control of the deadlines for the implementation of works.

CONCLUSIONS

For further development, the global identifier (GUID) can also be used in addition to the name [10]. This is necessary so that the exchange of information, which today depends on the names specified by the user, becomes interoperable and does not depend on the systems used. Such a mechanism is the Library of International Data Dictionaries [11].

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Расширение возможностей строительного контроля с внедрением технологий информационного моделирования для объектов многофункциональной недвижимости

Расширение возможностей строительного контроля с внедрением технологий информационного моделирования (ТИМ) — метод обеспечения организационно-технологической надежности создания объектов многофункциональной недвижимости, как инструмент наращивания результативности данного типа коммерческого строительства. Строительный контроль является одним из эффективных методов обеспечения организационно-технологической надежности создания объектов капитального строительства, использование современных технологий позволяет существенно увеличить их эффективность.

На сегодняшний день остается еще огромное количество вопросов и трудностей, с которыми каждый день сталкиваются проектировщики, строители, контрольные органы и другие участники данного направления. Крупные строительные компании уже приступили к тестированию и внедрению новых технологий.

С каждым годом технологии информационного моделирования в Российской Федерации все активнее применяются на всех этапах жизненного цикла объектов.

Сейчас довольно распространены технологии информационного моделирования в проектировании, несколько меньше на этапе строительства, и совсем незначительно на этапе эксплуатации зданий и сооружений. Существуют российские разработчики, которые создают под нужды современных реалий новое программное обеспечение, помогающее сократить время на выполнение рутинных процессов, сохранить и верифицировать информацию, донести ее до всех адресатов максимально быстро и без потерь[1].

В данной статье рассматриваются некоторые из подобных технологий, которые уже используются на этапе строительства и строительного контроля в единой среде общих данных. Это позволяет получать данные в нужный момент и в подходящем виде, без траты большого количества времени на всевозможные исправления, которые чем позже происходят, тем становятся более дорогостоящими.

На стадии проектирования, если проектировщику не приходят особые требования от заказчика, он вправе выполнять порученное ему задание любым удобным ему способом. Если же на начальном этапе планирования строительства какого-либо нового, либо реконструкции уже существующего объекта, со стороны заказчика будет формироваться пакет требований не только к промежуточным результатам всего инвестиционно-строительного проекта, но и требования к дальнейшим результатам работ (строительство и эксплуатация)[2]. Это позволит на ранних этапах четко выстраивать стратегию всех процессов, подобрать современные технологии, которые могут сократить множество издержек, и в особенности финансовые и временные затраты.

Ключевые слова: *стройконтроль, контроль, ТИМ, информация, технология, качество*

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For citation: Khrabrov A.P. Enhancing construction control possibilities with the implementation of information modelling technologies for multifunctional real estate objects. *Real Estate: Economics, Management*. 2023; 4:43-47.

Для цитирования: *Храбров А.П.* Enhancing construction control possibilities with the implementation of information modelling technologies for multifunctional real estate objects // Недвижимость: экономика, управление. 2023. № 4. С. 43–47.

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2 Об установлении случаев, при которых застройщиком, техническим заказчиком, лицом, обеспечивающим или осуществляющим подготовку обоснования инвестиций, и (или) лицом, ответственным за эксплуатацию объекта капитального строительства, обеспечиваются формирование и ведение информационной модели объекта капитального строительства : Постановление Правительства РФ от 5 марта 2021 г. № 331 (с изм. и доп. от: 20 декабря 2022 г.).

UDC 614.842.8

Gvozdev E.V.

Management of complex security of enterprises using the symbolic method

The formalized description of the symbolic method (complex numbers) is presented, by means of which the complex value is determined in the form of the level of influence of causal factors on the damage caused by accidents and fires. On the example of enterprises of oil and gas complex of Russia the substantiation on use of the symbolic method by means of which there is a possibility to receive adequate results of an estimation is presented. It is proposed to use software developed with the use of the method of hierarchy analysis and pairwise comparisons, as well as the method of Bayesian Belief Network. As an output, the task of determining the complex influence weight coefficient assigned to the report on accidents and fires at the considered enterprises is solved.

Keywords: *oil and gas complex, integrated security system, symbolic method, cognitive maps, influence coefficient*



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INTRODUCTION

The article considers the problem of integrated safety management (hereinafter — ISM) at the enterprises of oil and gas complex in Russia (hereinafter — enterprises of OGC in Russia) and proposes an approach based on the use of symbolic method for its solution.

The relevance of the presented problem lies in the need for the development and improvement of new expert knowledge, the need to search for new ideas, methods and tools based on the application of a specialized approach to the analysis of accident occurrence statistics at Russian OGC enterprises, which has not been previously used in the ISM at Russian OGC enterprises. This article is a development of the basics of complex and cognitive modelling to improve the ISM at Russian OGC enterprises; it was started in the studies [1–5].

BASIC COMPONENTS FOR THE APPLICATION OF THE SYMBOLIC METHOD

The methodological basis for obtaining new knowledge is the interdisciplinary approach, it gives an opportunity for obtaining new results with the reasonable use of technologies applied in both related and distant fields of science. It is defined as the integration of two or more scientific areas, technologies, etc. [6–7]. If knowledge exists, then with theoretical justification and correct transfer from one scientific sphere to another, it can become a means for obtaining results in a new researched area. Such is the application of the symbolic method (complex numbers) [8–11], further on its basis the construction of a cognitive model to assess the existing system of integrated security (hereinafter — SIS) at Russian OGC enterprises. The mathematical apparatus of the symbolic method (complex numbers) is successfully applied in various fields, for example, to determine the magnitude of deviation of characteristics (current from voltage) in electrical engineering. The use of the method of the symbolic method (complex numbers), allows to represent the instantaneous value of the investigated characteristic in the plane through the proved relationship between trigonometric functions and the exponent. Their application makes it possible to compactly outline the sequence in the build-up and development of conditions for the occurrence of dangerous events (accidents and fires) that cause damage (material and economic, sanitary and irrecoverable losses of personnel and third parties).

In order to improve the state of SIS at Russian OGC enterprises, knowledge and experience gained from accidents and fires[1] are taken into account and attention is paid to those cases when the accident and fire occurred sequentially after each other. The analysis of cause-and-effect relationships leading to the emergence of regularities, when one dangerous event (accident or fire) became the primary factor, it became a source of damage to another interacting subsystem can be realized using the symbolic method (complex numbers).

It is reasonable to consider a complex number used for solving problems in SIS at Russian OGC enterprises as a point and as a vector. For example, there is a vector displayed on the plane as $0\bar{Z}$ (Fig. 1) and $\bar{Z}$ its complex coordinate. When it is rotated around the point 0 by the angle φ (anticlockwise), the complex coordinate will be displayed on the sinusoid as the instantaneous value of the time period displayed on the scale *t*.

A complex number can be considered as a directed vector, or as a point that belongs to a differentiated (instantaneous) time index. An important geometrical interpretation of a complex number is noted. There is a vector $0\bar{C}$ in the plane (Fig. 2) and *C* is its complex coordinate.

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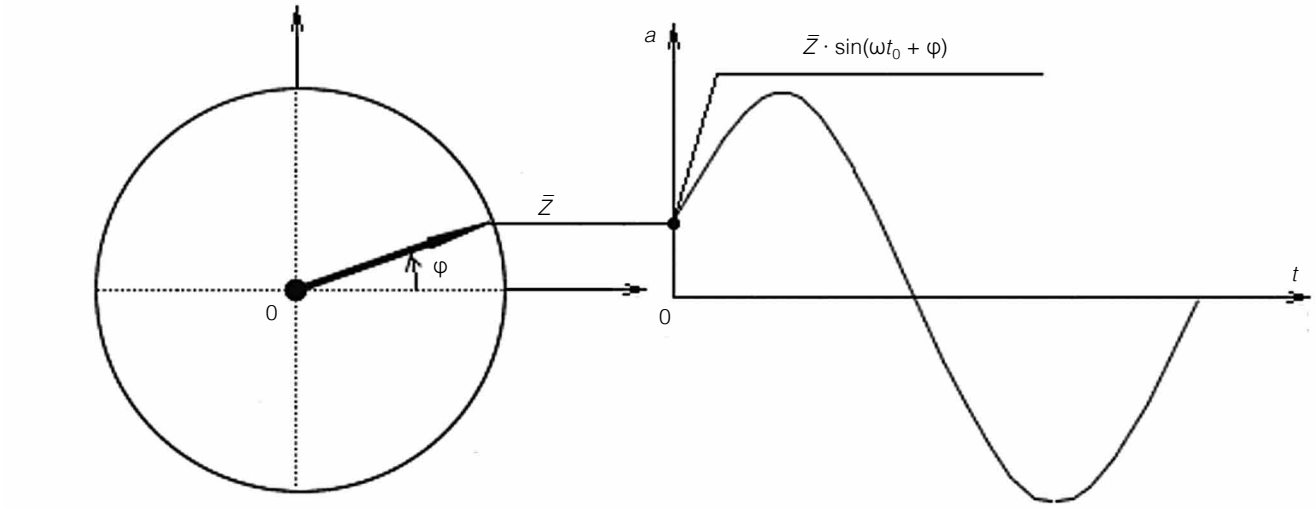


Fig. 1. Instantaneous value of a vector rotating on the plane

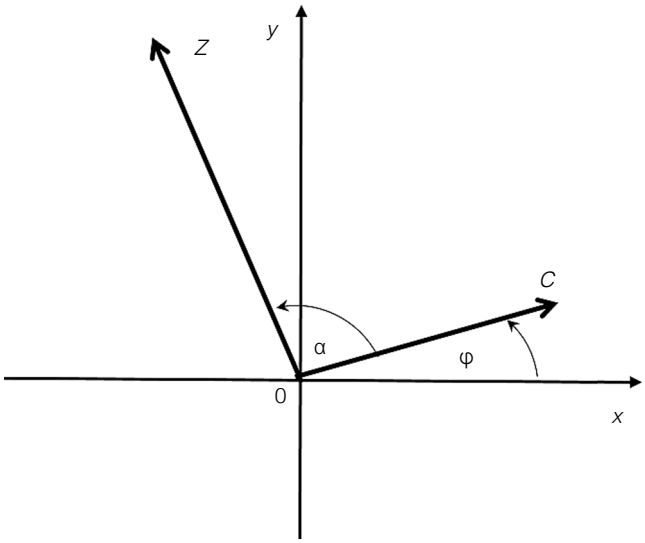


Fig. 2. Rotation of a vector on the complex plane

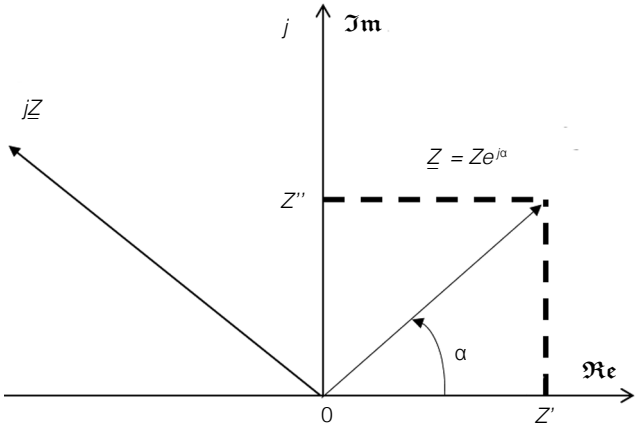


Fig. 3. Display of complex number values on the axes

When we rotate the vector around the initial point by an angle of α (anti-clockwise if α > 0, clockwise if α < 0) and stretch this vector by *n* times. As a result, a new vector $0\bar{Z}$ with complex coordinate *Z* will be obtained.

Any complex number $\underline{Z}$ can be represented (Fig. 3) in algebraic form:

$$\underline{Z} = Z' + jAZ'', \quad (1)$$

trigonometrically

$$Z = Z\cos\alpha + jZ\sin\alpha, \quad (2)$$

demonstratively

$$Z = Ze^{j\alpha}, \quad (3)$$

where

$$e^{j\alpha} = \cos\alpha + j\sin\alpha, \quad (4)$$

is called the Euler formula.

A vector on the complex plane, where $j = 1$, imaginary unit, $Z' = Z\cos\alpha$ is the real part of a complex number $\underline{Z}$ (projection of the vector onto the real axis of real $\mathfrak{Re}$ values); $Z'' = Z\sin\alpha$ is the imaginary part of a complex number $\underline{Z}$ (projection of the vector onto the imaginary $\mathfrak{Im}$ axis); $Z = |\underline{Z}| = \sqrt{Z'^2 + Z''^2}$ is the modulus of a complex number.

Since $e^{\pm\frac{\pi}{2}} = \pm j$, multiplying the complex number $\underline{Z}$ by *j* will increase its argument by $+\frac{\pi}{2}$ and rotate the vector representing the complex number $\underline{A}$ by an angle $+\frac{\pi}{2}$ in the positive direction, and multiplying by (–*j*) will decrease its argument by $-\frac{\pi}{2}$ and rotate the vector by the same angle in the negative direction.

Two complex numbers having equal moduli and equal but opposite in sign arguments are called conjugates.

For a complex number $\underline{Z} = Z' + jZ'' = Ze^{j\alpha}$, the conjugate is the complex number $\underline{Z}^* = Z' - jZ'' = Ze^{-j\alpha}$, with $\underline{Z}\underline{Z}^* = Z^2$.

Conclusion: any complex number, using the expression (4), can be represented in trigonometric form:

$$Ze^{j(\omega t + \varphi)} = Z\cos(\omega t + \varphi) + jZ\sin(\omega t + \varphi). \quad (5)$$

RATIONALE FOR THE USE OF SYMBOLIC METHOD FOR SOLVING PROBLEMS IN COMPLEX SECURITY OF ENTERPRISES

To assess the factors influencing the occurrence of joint hazardous events (accidents and fires) it was necessary to analyze the data on accidents[2] and fires[3] for the period of 7 years during which there were accidents according to Rostechnadzor statistics — 412 cases; fires according to the statistics of the Ministry of Emergency Situations of Russia — 1,354 cases; deaths of employees of enterprises — 227 people were recorded, about 600 people were injured. There were 21 cases of impact on the ecological environment [2].

The symbolic method (complex numbers) is based on the use of transformations of the investigated characteristics, which are presented (see Fig. 4).

On the upper part of the graph with the axis $\mathfrak{Re}$ and $\mathfrak{Im}$ values, the areas of primary and secondary influencing factors from accidents — *I*, fires — *U*, are presented, where each of the considered hazardous events can occupy the corresponding area.

The complex value on the influence of factors causing damage from hazardous events (accidents and fires) is a vector, considered as indicators *Z* for the domain of primary factors and *C* for secondary factors, mapped to an angle of deviation φ; –φ. The angle α will be used in the calculations for the equivalent determination of the magnitude of influence on damage from hazardous events (accidents and fires). In complex form, the record can be represented as a system of equations:

$$\left.\begin{aligned} \underline{I} &= Ie^{j(\pm\pi/2\pm\varphi)} \\ \underline{U} &= Ue^{j(\pm\pi/2\pm\varphi)} \end{aligned}\right\}. \qquad (6)$$

The essence of using the symbolic method (complex numbers) is that using the above transformations it is possible to go from the system of differential equations for real functions of time to the system of algebraic equations with influencing complex indicators of damage from accidents and fires. Transition from differential equations to complex equations is carried out by replacing in them instantaneous values of primary and secondary influencing factors *I*, *U* (formulas (1)–(6)).

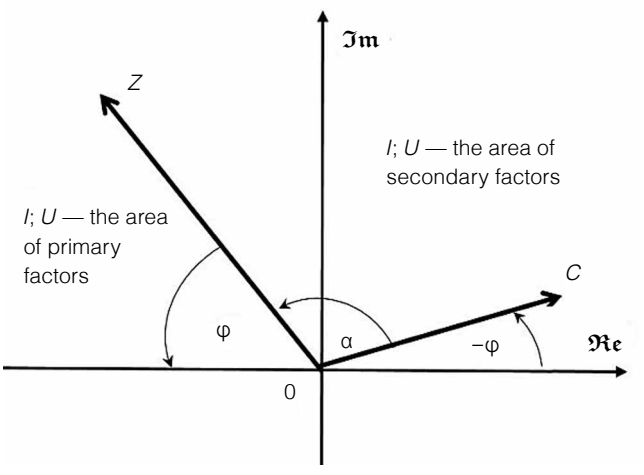


Fig. 4. Areas under consideration and characteristics displayed on the axes

In equation (6), the indicator *e,* is considered as a numerical value displayed as a level value of the influencing value of the occurrence of a hazardous event (accident and fire), its indicator is required to be determined using sound methods.

EXAMPLE ON THE USE OF THE SYMBOLIC METHOD TO ASSESS THE IMPACT OF ACCIDENTS AND FIRES ON THE INTEGRATED SAFETY OF ENTERPRISES

The total damage *U* at the enterprises of OGC of Russia was calculated through the sum of damages related to the types of its component processes of production $U_{(E, P, S, T, Ot)}$, inflicted to the objects of technosphere protection (personnel, materiel and equipment), which was evaluated taking into account quantitative indicators: human losses (sanitary and irrecoverable); by economic damage in rubles (Table 1).

$$U = F_U\{U_E, U_P, U_S, U_T, U_{Ot}\} = \\ = \sum\left[F_{U_{(E,P,S,T,Ot)}}(U_E, U_P, U_S, U_T, U_{Ot})\right]\cdot q_{(0.1-1)}, \qquad (7)$$

where *E* — extraction; *P* — processing; *S* — storage; *T* — transportation; *Ot* — other.

The framework for selecting indicators with the normalizing factor *q* is determined with the help of experts, its values are presented in Table 1.

Further, to carry out calculations using the symbolic method (complex numbers), it is proposed to use a vector-directional symmetric model (Fig. 5).

A symmetric model for assessing the influence of causal factors related to the analyzed accident reports, in the content of which are presented the areas *I* and *U* — primary and secondary factors. Each domain is equipped with a limit level measured in degrees from the axis with real $\mathfrak{Re}$ — values.

To assess the factors affecting the damage caused by accidents and fires, we used the symbolic method (complex numbers) and the programme "*Rating Data Generator for the assessment of industrial and fire safety at enterprises of the oil and gas complex of Russia*" designed to create a rating list of activities that caused

Table 1. Examination results for the use of the normalizing factor q

q	Casualties, persons	Victims, persons	Damage, thousand roubles
q = 1	> 5	> 20	> 50,000.0
q = 0.9	3 to 5	10 to 20	from 1,000.0 to 50,000.0
q = 0.8	1–2	5 to 10	from 1,000.0 to 50,000.0
q = 0.7	–	1 to 5	from 1,000.0 to 50,000.0
q = 0.6	–	–	> 50,000.0
q = 0.5	–	–	from 1,000.0 to 50,000.0
q = 0.4	–	–	from 1,000.0 to 50,000.0
q = 0.3	–	–	500.0 to 1,000.0
q = 0.2	–	–	from 500.0
q = 0.1	–	–	–

2 Information on accidents at Russian oil and gas companies. URL: https://www.gosnadzor.ru/industrial/oil/lessons/

3 Letter from the Head of FSBI VNIIPO of the Ministry of Emergency Situations of Russia "On submission of fire record cards" No. 652 1 29 11 6 dated 06.04.2020.

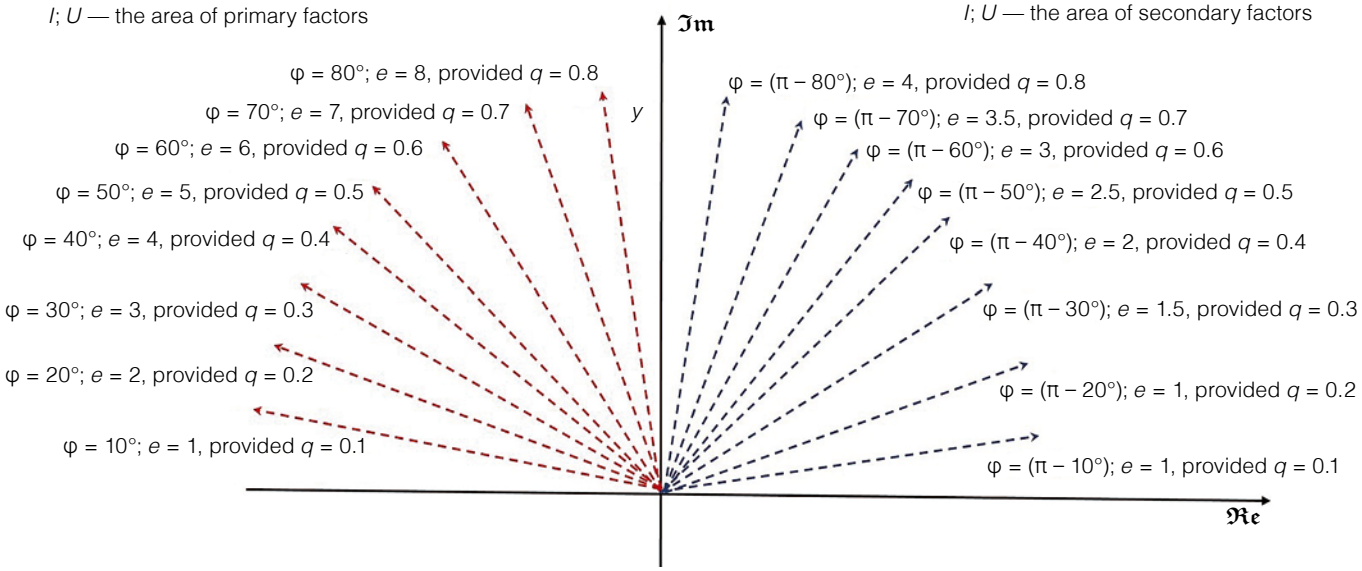


Fig. 5. Symmetric model for determining the assessment of the influence of factors

the occurrence of dangerous events (accidents and fires)[4] [13]. The general rating list can be specified for each of the directions of functioning of the production process considered for the enterprises (*E*; *P*; *S*; *T*; *Ot*). In addition, each of the activities presented in the list can be analyzed using the programme "Netica", which will provide an output for each cause — the indicator of recurrence for the period under study. Further, for each report from the generated sample of accident and fire statistics, it will be possible to determine its own estimated level of impact on damage. An example with a fragment of indicator selection is presented (see Table. 2 and Fig. 6).

The results presented in the table are reflected in the vector diagram (Fig. 6), taking into account the peculiarity of the frequency of recurrence of events during the study period (i.e. during the year).

For evaluation of the report No. 1 with organizational measures (Table 2) the indicator put off on the axis of imaginary Im values from the area of primary factors will correspond to 0.9, and from the area of secondary factors will correspond to the indicator 0.45. To determine the value of influence of *Z* causal factors of organizational

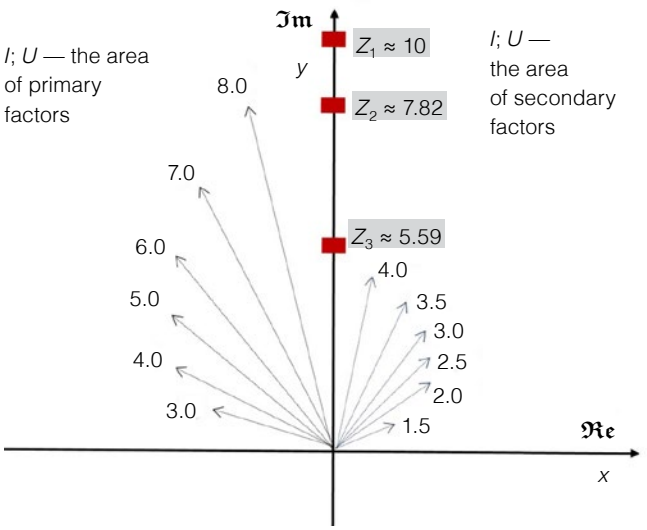


Fig. 6. Model showing the results of the integrated assessment indicators

Table 2. Information with reports on organizational and technical causes of damage from accidents

Date	Enterprise	Organizational reasons	Casualties, pers.	Injured, pers.	Damage, thousand roubles	Regulatory coefficient *q*	Repetition rate (per period)*
19.04. 2019	PJSC Nizhnekamskneftekhim TAIF Group of Companies	Violation of the procedure for carrying out preparatory work for scheduled repairs of process equipment …	4	13	4,200.0	0.9	1
06.02.2015	LLC LUKOIL-Perm, LLC Universal Stroy, OJSC LUKOIL	Violation of the technology of construction and installation works at an operating field gas pipeline	–	1	1,466.0	0.7	1
18.06.2017	SUE MR Mosoblgaz, Mytishchimezhraygaz	Work in the protection zone of an underground gas pipeline without written permission from the organization operating the gas distribution network	–	–	899.0	0.3	3

** for each increase in the frequency of occurrence of a hazardous event >1, one level rank higher from the domain of primary and secondary factors of the vector-directional symmetric model is added.*

4 Gvozdev E.V., Migalchinskiy N.M., Koldin T.E., Sinyakin D.S. State Registration Certificate for Computer Software No. 2023611653, Russian Federation. Rating data maker for evaluation of industrial and fire safety at enterprises of oil and gas industry of Russia. No. 2023610660; appl. 01.16.2023; publ. 01.24.2023. (rus.).

causes on the level of inflicted damage (Fig. 6) it is advisable to perform an algebraic calculation according to the formula:

$$Z = \sqrt{A_1^2 + A_2^2}, \quad (8)$$

where A_1 and A_2 are indicators with results taken from the areas of primary and secondary factors affecting damage.

Estimated indicators in the form of coefficients affecting the level of damage caused by accidents for reports No. 1–3 are presented below (see Table 2), where:

$$Z_1 = \sqrt{9^2 + 4.5^2} \approx 10.0;$$

$$Z_2 = \sqrt{7^2 + 3.5^2} = 7.82;$$

$$Z_3 = \sqrt{5^2 + 2.5^2} = 5.59.$$

CONCLUSION

The article substantiates the possibility of using the symbolic method (complex numbers) to solve problems in the management of SIS at Russian oil and gas companies. An example proving the adequacy of using the method described in the article in practice is presented.

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Управление комплексной безопасностью предприятий с использованием символического метода

Представлено формализованное описание символического метода (комплексных чисел), с помощью которого определяется комплексная величина в виде уровня влияния причинно-следственных факторов на наносимый ущерб от аварий и пожаров. На примере предприятий нефтегазового комплекса России представлено обоснование по использованию символического метода, с помощью которого имеется возможность получить адекватные результаты оценки. Предложено использовать программное обеспечение, разработанное с применением метода анализа иерархий и попарных сравнений, а также метода Байесовских сетей доверия. На выходе решается задача по определению комплексного весового коэффициента влияния, закрепленного за отчетом об авариях и пожарах на рассматриваемых предприятиях.

Ключевые слова: *нефтегазовый комплекс, система комплексной безопасности, символический метод, когнитивные карты, коэффициент влияния*

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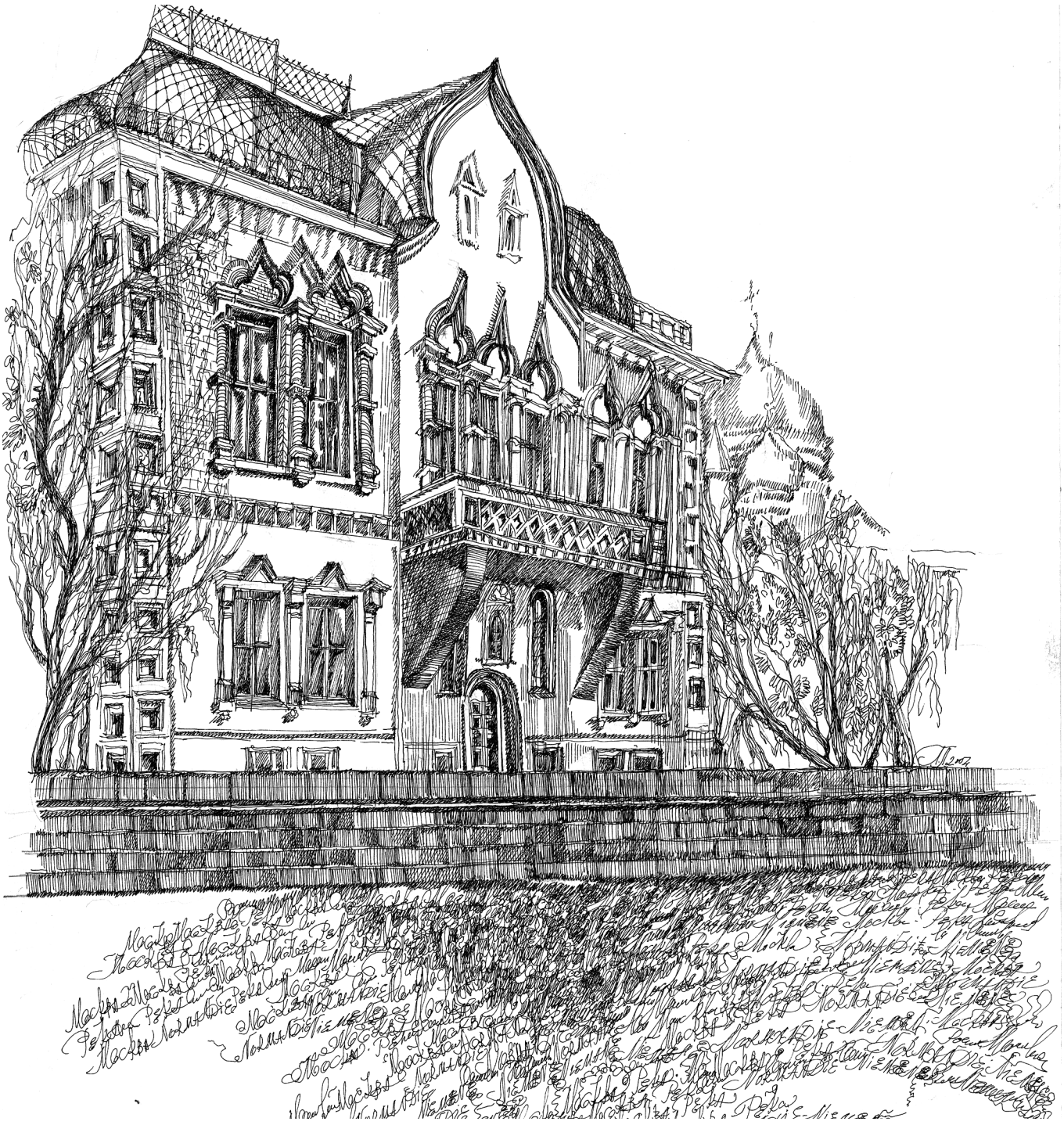
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For citation: Gvozdev E.V. Management of complex security of enterprises using the symbolic method. *Real Estate: Economics, Management*. 2023; 4:48-53.

Для цитирования: *Гвоздев Е.В.* Management of complex security of enterprises using the symbolic method // Недвижимость: экономика, управление. 2023. № 4. С. 48–53.

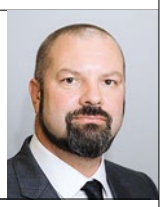


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UDC 624:621.039, 658:519.7:004.5, 658:519.8

Sezemin D.E.

Membrane method in assessment of organizational and technical reliability of NPP construction projects



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The materials of the presented research paper are based on the analysis of recommendations for improving the organizational and technical reliability of planned solutions in the conditions of system risk at the stage of preparation and the main phase of construction of large industrial complexes, such as a nuclear power plant (NPP). The system analysis carried out by the author forms the basis for methodology recommendations on the selection of a rational option of work plan for the construction of a technically complex industrial facility. The conclusions are made on the basis of the development by the author of his own simulation model of risk analysis using a modern approach to the application of automated systems for scheduling production processes of NPP project implementation, including at the international intergovernmental level.
The research paper characterizes theoretical methods and practical recommendations for the development and selection of a rational variant of work organization at the NPP construction site at all stages of the project life cycle. As a basis for selecting the most rational work organization plan, the author proposes to develop and implement a simulation model on the basis of the Membrane Method, which accumulates data for comparative analysis of the results of all project systems. The essence of this Membrane model is described below.
The paper presents the main requirements to the technical specification for the domestic development of software for processing the data of risk analysis for the NPP construction project realization at each stage of the project life cycle.

Keywords: *nuclear power plant (NPP), NPP construction, NPP reliability management, NPP construction risk management, construction economics, industrial construction, multi-criteria reliability assessment, enterprise economics, mathematical modelling, machine risk modelling, automatic control system*

INTRODUCTION

In the presented research paper, the author identifies the challenges of the modern international market of nuclear energy, analyses domestic and international experience in the construction of technically complex megaprojects, studies and systematizes organizational and technical aspects of the concept of reliability and risks of technically complex industrial facilities, based on the example of an international project for the construction of a nuclear power plant (NPP).

The author seeks to solve one of the most important problems — to define risk and its assessment in an inextricable connection with the life cycle stages of projects in the field of peaceful atom applications.

Both the principles of assessment of organizational and technical reliability of the system under study and the methods of reliability and risk assessment have been systematized. The author developed his own multi-criteria approach to the concept of reliability using modern theoretical methods in the context of the development of NPP construction projects abroad, taking into account global and intergovernmental risks.

Analysing the methodological recommendations for improving the system of preparation and execution of construction works of large and technically complex industrial complexes, the author proposes ways to improve the organizational and technical reliability of design solutions under risk conditions. Thus, the author develops and implements his own concepts and methods of reliability and risk assessment, namely the Membrane Method of NPP risk estimation by Sezemin D.E. This method views each stage of the project life cycle as a layer of membrane, where first one or another risk emerges and then passes, or rather, “germinates” or evolves into the next layer (the next stage of the project life cycle), having the opportunity to pass through all layers of the membrane or, conversely, end on a certain layer, having had its impact. Risks can grow, appear or disappear at any stage, starting from the first and ending at the top of the layers. The development of the software, necessary and recommended by the author of this paper, based on the membrane method will allow visualizing (by adding a contrasting colour) how much the risk affects the final target parameters of the whole system. Introducing the concept of “target parameters of the NPP construction system”, the author adopts the following four parameters of the system: timing, economic efficiency, quality, and safety, associating them with the four corners of a square. The presented description of the membrane model in the form of a three-dimensional figure allows visualizing in the form of an image, as well as in the form of a risk dynamics graph, the main aspects of the investigated problem:

- the fact of risk existence;
- the stage of risk occurrence;
- the stage of risk impact termination;
- at all stages of the life cycle, the impact of each of the risks separately on the system of the organizational and technical reliability of the project;

- the impact of all risks on the system, assessed by four angular parameters;
- the assessment of the risk impact can be done before and after taking compensating measures.

THE MEMBRANE METHOD

Having analysed current theoretical and practical problems faced by the executor and the customer of EPC-contracts[1] used as a modern risk management tool[2], the author sees the need for a comprehensive study of the issues related to non-performance, improper performance, liability, and risks of failure to achieve or obtain the full economic effect from the realization of megaprojects that are implemented on the basis of international contracts and intergovernmental agreements. These issues are becoming increasingly relevant in the field of nuclear energy and peaceful atom applications.

At the same time, the very application of the EPC-contract in NPP project realization, on the one hand, allows the transfer and delegation of risks, and on the other hand, the system of risk management itself, mitigation and compensation of their consequences is transferred to the contractor's area of responsibility, while the project risks themselves are retained and even increased, or new types of risks are added. In this publication, therefore, the idea of risk mitigation and management through the EPC-contract is seen as not dominant, and risks are treated in their pure form impersonally and independent of economic agents, Customer or Contractor.

The basis for the preparation of this paper is a thorough long-term analysis of scientific and methodological recommendations for improving organizational and technical reliability of design solutions under risk conditions at various stages of the NPP project life cycle. This work allows the author to develop his own recommendations on selecting a sound risk management option and to develop the terms of reference for a new national automated process control system. As a basis for the terms of reference, it is proposed to apply the newly developed membrane method of risk assessment and management.

When developing the concept of our own methodology of reliability assessment and risk management, it should be noted that one of the fundamentals of such management is the development of a certain management strategy, when an individual reliability and risk management strategy is implemented at the enterprise. The methodology determined by the modern development of the scientific and technical sphere recommends applying long-term, medium-term and short-term strategic planning, which is also acceptable for reliability and risk management of the main phases of the life cycle of the NPP construction project.

Management of both internal and external risks can be carried out on the basis of a specially created ACS TP (automated control system of technical processes) at the enterprise, which is a set of hardware and software that monitors and controls production and technological processes, maintains continuous feedback and actively influences the process in case of deviation from the specified parameters, as well as provides regulation and optimization of the controlled process. On the basis of his own developments and methods described in this publication, the author proposes to take the following requirements for the ACS development as a basis for the technical specification:

- the product should be designed to automate a specific facility;
- the product stabilizes the specified modes of the technological process by measuring and processing the values of technological parameters, visualizing and issuing control actions (in real time) on the working mechanisms in automatic and semi-automatic mode (if applicable to a particular production process, taking into account the technologist-operator's actions);
- the product analyses the current state of the technological process, allows to identify pre-emergency situations and prevent accidents by transferring technological units to a safe state, both automatically and under the control of operating personnel;
- the product provides the engineering and technical personnel of the enterprise with the necessary information about the technological process for solving the problems of control, accounting, analysis, planning and management of the production process.

In a broad sense, the engineered ACS, in our opinion, should be based on a feasibility study of the NPP project, which specifies the capacity of the NPP, the number of power units, the number of reactors within a reasonable feasibility study, specifies the region of construction, estimates the investment volume of investment, and includes calculation of the project payback, project profitability and return on investment.

Further, the author proposes to divide the ACS into levels and suggests the following division acceptable for NPPs:

1. The level of technological process (field level).
2. The level of control and management of the technological process (controller level).
3. Baseline network level (network).
4. The level of man-machine equipment (top level).

As a result of the conducted research, the basic principles of the cybernetic model of a modern Russian-made ACS for NPP projects have been determined. The development stages include the following steps (Note: the presented plan is equally applicable to the development of the proposed risk assessment and management method):

1. Definition of technical requirements to the control and management system.
2. Development of design and cost estimate documentation.
3. Collection and analysis of initial data.
4. Compilation of a complete list of variables.
5. Completion of the ACS system (risk assessment).
6. Division of the control facility into technological sections and subsequent allocation of variables to sections and groups.
7. Creation of in-house databases (libraries).
8. Creation of a graphical interface of the screens of operators and control personnel (links) alternately in dynamics and statics.
9. Creation of transition schemes from static to dynamic images on screens.
10. Development of control algorithms (for all possible modes of operation of the facility, including emergency and post-emergency).
11. Creating the possibility of generating printed documents by sending to printers in subdivisions (in order to save time).
12. Verification of databases.
13. Preparation of operational documentation.
14. Testing of the system in stand-alone mode.

1 Engineering, procurement, and construction. URL: https://ru.wikipedia.org/wiki/EPC_(контракт)

2 EPC contract. Neftegaz.RU. URL: https://neftegaz.ru/tech-library/menedzhment/141747-epc-podryad-kontrakt/#:~:text=EPC%20-%20контракт%20(Engineering%2C%20Procurement%2C,фиксированной%20цене%20к%20фиксированной%20дате

15. Testing of the system in operational mode.
16. Formal implementation, commissioning, personnel training, issuance of relevant orders and instructions.

In the proposed risk management model, the development of the ACS TP model at the feasibility study is a strategically planned step. In parallel with the risk management model, a system of continuous risk assessment and control is being implemented, leading to the achievement of the main four project objectives, such as:

1) project timeline;
2) costs;
3) project quality;
4) project safety and security.

The membrane method of risk assessment is based on the algorithm for calculating the full economic result of the risk management strategy for each stage of the NPP project life cycle. For the purposes of this study, the following steps or layers of a membrane-based risk management approach are identified, followed by software development based on the membrane method of risk management:

1. Initiation.
2. Planning.
3. Development of criteria and strategy for NPP location (interrelated with items 3–6, 9).
4. Design (interrelated with 1, 3–9).
5. Construction (interrelated with 1).
6. Commissioning.
7. Operation.
8. Extension of operation (modernization).
9. Termination of operation.
10. Shutdown of processes.
11. Decommissioning [1].

Each of the eleven project phases represents a layer of the risk assessment membrane system (Fig. 1, Table 1, 2).

Risk accounting and analysis by membrane method will allow to present calculation of the full economic result of the risk management strategy for each period of project development (Fig. 2).

The 3D representation of the membrane method (membrane model) is as follows: risks by groups form the membrane layers, which, in turn, form the so-called “membrane pie” by stacking layers on top of each other The layers are arranged horizontally in the order of the life cycle stages of the project of a technically complex facility — a NPP. The lattice of stacked membranes has several effects: “spring effect,” “impermeability effect” (hereinafter impermeability is understood as the optimal degree of overall project reliability), and “layer – problem – balance” effect. It should be noted that the description of the membrane method with the help of a 3D picture gives an idea of the significance and relevance of the task of systematization and digitalization of big data in the field

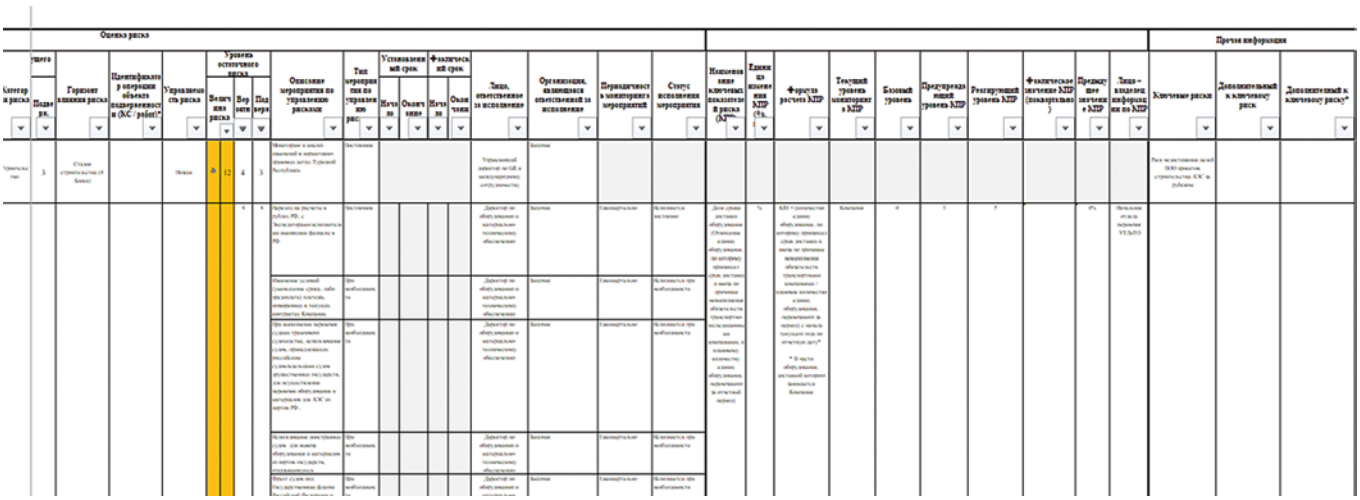


Fig. 1. Example of a risk summary table

Table 1. Example of a summary table of risk factor impact assessment

Impact on volume	Impact on safety	Impact on the public	Impact assessment
Changes in volumes can be covered by current contractual obligations	The assessment of the impact of risks on safety is carried out in accordance with the requirements of current legislation and local regulations. Methods of risk prioritization, scoring scales and significance criteria for environmental safety, industrial safety, occupational safety, information security and other related risks are set out in special documents issued under the Project	The level of decrease in public trust at the local level is insignificant	1
Additional agreements are required within the existing contractual framework		Decrease in the level of public confidence at the local level. Short recovery period	2
Additional agreements with Contractors required		Decline in public confidence at the regional level. Short/moderate recovery period	3
Additional agreements with the Client required		Decline in public confidence at the international/regional level or at the level of important partners. Moderate/long recovery period	4
Revision of substantial terms of EPC contract/ contract with Tier 1 Contractor required		Damage to public trust at international or key partner level. Long recovery period	5

Table 2. Assessment of the impact of risks with background colouring

Probability	Impact assessment				
	1 Very low	2 Low	3 Medium	4 High	5 Very high
5 Very high	5	10	15	20	25
4 High	4	8	12	16	20
3 Medium	3	6	9	12	15
2 Low	2	4	6	8	10
1 Very low	1	2	3	4	5

of assessment and reduction of the maximum possible number of risks in the work of technically and organizationally complex construction projects.

The membrane method of reliability and risk assessment of a technically complex production system is based on the following concepts:

1. Risk value — an indicator that determines the weight (significance) of a particular type of risk in relation to other (accepted in the system) types of risk.
2. Risk register — types of risks defined as significant for a particular technically complex production system.
3. Risk probability degree — probable, unlikely or improbable possibility of occurrence of the given type of risk depending on the possibility of occurrence.
4. Risk expert panel — a collegial body (project team) specially formed for the project realization, which includes experts for each type of risk, as well as staff and engaged specialists for the development and implementation of software representing the corresponding membrane-type simulation model.
5. Acceptable risk — the amount of risk that is tolerated by the simulation membrane model.
6. Compensatory measures — a set of actions leading to reduction of the risk value to an acceptable one.

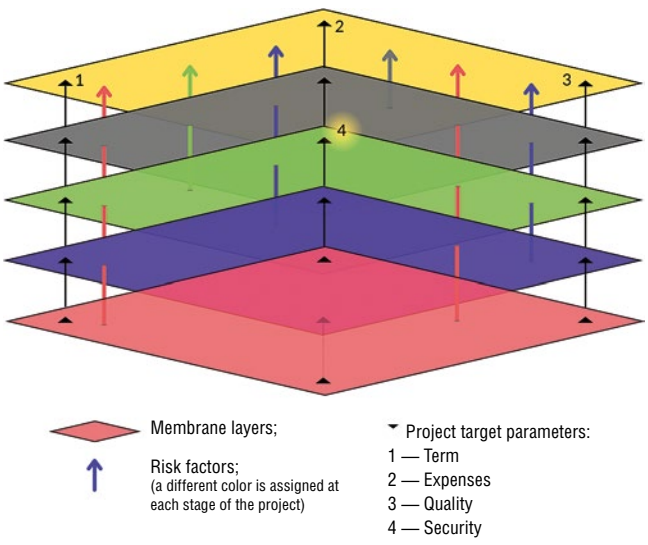


Fig. 2. Illustration of the Membrane Method for assessing the organizational and technical reliability of a project

7. Main risks — the most significant risks in terms of their magnitude.
8. Risk — a possible danger, threat of an adverse event, as well as an unexpected (including favourable) result of actions or event development, measured through the probability of event occurrence and the amount of damage (result adjustment) from a certain action [2].
9. Risk owner — a person responsible for a certain risk or group of risks within the project at all stages of the project life cycle.
10. Risk response strategy — a decision based on the outcome of risk and its economic effect, including such types as (from smaller to larger) reduction, acceptance, increase to an acceptable value, elimination, postponement of the stage[3].
11. Risk management — a system adopted at the enterprise, aimed at influencing the risks identified or predicted and modelled in the course of analysis.
12. Risk factor — cause, event, action (inaction), activity, influencing the occurrence and possibility of risk adjustment.
13. Risk management measures — planned and emergency measures taken to manage risks.
14. Risk immanence — a state of the system, in which the risk, as well as its analysis and management are a permanent internal property of the system, inherent in the project at all stages of its life cycle and requiring continuous ongoing monitoring, due to empirically achieved understanding of the possibility of new unplanned risks at any stage of implementation of a technically complex project.
15. Risk reporting — the process of preparation and approval of data on risk analysis, results of risk analysis, measures taken to manage risks and the economic effect of these measures, formalized (reported) in accordance with the internal regulations of the company, as well as the requirements of GOSTs for each risk or group of risks at each stage of the life cycle of a technically complex project.

In order to form a risk analysis system based on membrane-based reliability and risk management, we propose to divide the process into the following steps:

1. Search and identification of risks.
2. Verification of risks with the help of system methods used in the organization (checklist, decision tree, event tree, "what will happen if" method, as well as the expert method described in detail in Chapter 2 of the presented qualification work).
3. Entering risks into a unified system adopted at the enterprise and using network schedules, test reports, surveys of specialists with data entry into questionnaires, which is described in detail and systematized by the author in Chapter 2 of the presented qualification work.
4. Identification of planned risk parameters, deviations from which are planned to be controlled and, if necessary, corrected subsequently at all stages of the system life cycle.
5. General description of risk is performed for all types of risk and includes:
   - description of risk;
   - possible consequences of risk by options;
   - the impact of risk on the timing of the project;
   - the monetary value of risk, affecting the total cost of the project; in this case, compensation measures,

3 In the presented work the concept of risk transfer to an external counterparty is not considered due to the fact that, regardless of the risk owner, this risk is to be managed as a contractual arrangement and on the basis of labour relations and internal regulations of the company; the risk owner does not change, and his competence is expanded, integrating the function of "risk curator" that is, the person responsible for interaction with the counterparty who technically accepts the risk.

the decision taken, as well as the result of such a decision are formalized at a later stage of the membrane-based risk management process.

The general formulation of the risk should contain, in addition to the name of the risk, its causes, consequences of its occurrence and the degree of impact on the project objectives, according to the membrane method, and an assessment of the impact on the overall economic performance of the project.

It should be noted that to assess the risks of technically complex production systems, the author proposes to abandon the often used so-called pyramidal system of risk accounting, based on hierarchical structuring of risks, because newly emerging risks at any stage of the life cycle of the system can and will claim a more important place in the already formed pyramid of risks. The membrane type of risk stacking allows to supplement the already existing risk structure with risks added to the system and to create an interpenetrating fine-mesh structure of all risks of the project.

6. After determining all risks of the system (with understanding of the immanence of risks of the project system), their classification is carried out, which can be based on the method of TECOP SH — technical, economic, commercial, organizational, political, supplemented by the author of this research qualification work by the classification oh the social-humanitarian principle, including such groups of risks as demographic, the position of the company in society, its reputation, etc., as the basic approach to the classification of risks[4] [3] .
7. Risk assessment — the result of the risk assessment process is the determination of the impact of a certain risk on the project parameters included in the feasibility study. Qualitative risks are divided by the degree of influence on the project; quantitative risks differ on the basis of probabilistic assessment.

Table 3. Risk scale. Layer 1

Type of budget risk for project implementation	Budget growth in % up to 1 %	Budget growth from 1 to 2 %	Budget growth from 2 to 3 %	Budget growth from 3 to 4 %	Budget growth from 4 to 5 %	Budget growth from 5 to 6 % and so on
Design delay						
Delay in construction works						
Delay in equipment delivery						
Level 1 human error resulting in accident and equipment failure (by type of equipment)						
Changes in average annual air temperature by 1° C						
Currency exchange rate fluctuations						
Strike of transport workers for 10 days or more						

Table 4. Risk scale. Layer 2

Target indicator		Weight/qualitative indicator				
		Item No.	Item No.	Item No.	Item No.	Item No.
Budget	Operational costs	Increase by 1 %	Increase by 2 %	–	–	–
	Capital expenditures					
Schedule		Delayed by 0 month	Delayed by 1–2 months	Delayed by 3–4 months	–	–
Quality		No deterioration	Minor impact (on part of project activities), possible adjustment	Requires Client approval	Unacceptable	The project is better not to be implemented in this capacity
Safety	ecological	On the basis of a specially created expert panel, legislative requirements and internal regulations and rules, an appropriate membrane layer of risk impact on project safety is described, taking into account the assessment of costs to ensure the required level of safety. It is included in the terms of reference for the development of software for the risk assessment system using the membrane method				
	industrial					
	information					
	labour safety					

4 According to the data collected by the authors of the paper "Development of risk classifier as a stage of successful risk management" published in the scientific and practical journal "Problems of risk analysis", Rosatom Corporation uses the TECOP classification as a basic approach to the classification of risks. This classification was the basis for the development of the Electronic Risk Classifier as part of the Unified System of Classification and Coding of Nuclear Energy (USCC NE).

For qualitative assessment of risks, the author proposes to introduce weighting of each risk individually and in groups, with a total weight of 100.

The author of the presented research and qualification work proposes to identify four main target parameters, which are affected by risks (groups of risks) and in general the risk exposure of the enterprise, namely:

- project realization timeline;
- budget of the project realization;
- quality of the project and its products;
- project safety.

For the Project Implementation Budget indicator it possible to introduce the following system of data recording on risk analysis types, expert assessment of their impact on the target indicator of the project, and the weight of each risk (Table 3, 4).

8. Risk ranking. The assessment is made by evaluating the impact of the relevant risk on the project targets, having previously determined the magnitude of each risk by applying the previously described scoring system — the probability of risk occurrence and the risk exposure of the system. The formula is straightforward:

$$R = P \cdot V,$$

where R is scoring of the value of a particular risk; P is score risk assessment; V is scoring of the system exposure to the risk.

Here a convenient method is to fill in the table with values of negative consequences of risks or the matrix of possibilities (positive consequences) in the form of a table of risks in the form of a table (it is not the values themselves that matter, but the location of their gradient in Table 5).

9. Identify recommended strategies for the effective impact of risk management activities on project targets.
10. Present the data to the risk expert panel. The results are summarized in a table using the following example (Table 6).

Table 5. Gradient arrangement of risks

Probability	Impact assessment				
	Very low	Low	Medium	High	Very high
Very high					
High					
Medium					
Low					
Very low					

Table 6. Development of strategies and interventions based on the risk score determination

Risk score (determined by experts)	Strategy	Measures
1–4	Acceptance	Control measures
4–15	Control (reduction)	Compensatory measures, continuous monitoring
15–25	Reduction, rejection	Compensatory measures, continuous monitoring

11. Calculation of residual risk after application of compensating measures is the next stage of the algorithm of work with the risk management system. The calculation is recommended to be carried out in two directions: assessment of the possibility of influence on the probability of occurrence of a risk event and assessment of risk on the possibility of application of compensating measures. Here the derived function formula is applied, similar to the risk analysis, when the value of multipliers is reduced by the value of manageability for each type of multiplier. Manageability can also be determined by expert judgment, when each score (on a selected scale) is assigned a degree from 0 to 100.

The final value of residual risk is calculated as arithmetic mean of the normal Gaussian distribution, where the upper and lower values of the studied parameter are not included into the area of analysis.

For quantitative assessment of risks, simulation models are used. Each risk is assigned a rating in the form of a number, the impact of risks on the project is assessed both for each risk separately and for all of them together. After reducing the degree of risk, a second assessment is done, based on the identified trends, and a decision is made on the further implementation of compensatory measures. The Monte Carlo method is used, based on the use of random number sampling. A special algorithm assigns a random event, with the help of which the probabilistic problem is solved. This method replaces complex algebraic computations in the following three cases:

- when modelling complex operations with interaction of many random factors;
- when verifying the applicability of analytical methods of research and clarifying the conditions of their applicability; it should be taken into account that the calculations are carried out repeatedly (e.g., 100 times);
- when developing corrections to empirically derived analytical formulas [4].

Speaking about the proposed method of risk assessment, it should be noted that the author uses the parametric method as a sub-method (for systems that do not have well-defined planned costs and terms of implementation, in particular, for the assessment of projects at the feasibility study stage). An example of a risk assessed by such a sub-method is the probability of failure to build a nuclear power facility in a given location, as in the case of the transfer of the construction site of the Turkish NPP to Akkuyu from another province. In 1980, the planned location for the NPP was Inceburun in Sinop province, and later it was transferred to Akkuyu, the Gulnar district of Mersin; “in 2017, the Turkish Atomic Energy Agency approved the design parameters of the Akkuyu NPP site” [5]. This case is also suitable for risk assessment using the parametric method due to the on-going situation with the postponement of the launch date and, in general, the entire realization of the Turkish NPP project.

Based on the results of identifying all possible types of risks and their assessment using the presented methodological approaches, risk registers are developed, both integrated (for the entire project) and localized (by project subdivisions), and experts on a particular type of risk are involved in the finalization of each of the registers.

The author of the presented research proposes to organize the activity within a single scale from risk acceptance to risk avoidance (exclusion of action) and then divide the risks into groups depending on the degree of riskiness of action:

1. Acceptable risks are those that can be accepted at a given stage of the project life cycle; it should be noted that risks at different stages of the project life cycle are also distinguished

by the degree and the actions that need to be taken to bring the risk to an acceptable level.

2. Risks that should be reduced are those whose management reduces the likelihood of an event. Staff training is a prime example.
3. Risks that should be increased are those leading to positive effects for the project.
4. Planned risks are risks for which it is possible and acceptable to develop and implement an action plan to reduce risk to acceptable levels.
5. Transferable risks, for which the best solution is to transfer them on a contractual basis under certain guarantees and responsibility of the contractor.
6. Avoidable risks are those that result in the avoidance of a given action or such a significant change in the operation of the system that eliminates the risk.

The author believes it is advisable to separately identify and analyse the risks that may hinder the implementation of strategic goals of the State Corporation through the implementation of a specific NPP construction project, namely:

- increasing the share in the international nuclear power markets;
- reduction of production costs;
- reduction of production process time;
- introduction of new products to the market;
- global leadership in the field of technology [3].

Risk analysis through the membrane of strategic goals of Rosatom State Corporation is the most important objective of the methodology developed by the author of the research work.

The introduction of the membrane method of risk assessment allows monitoring of all types of risks at all stages of the NPP construction project life cycle due to the unified systematization of all types of risks in one software program. This constant monitoring is achieved by the idea of development and implementation of a subfunction of regular system queries within a single software product. This software should work similarly to the M2 DSS banking product, which links the registration of a real estate transaction with the fact of its payment by disclosure of a confirmed letter of credit, sending electronic requests to the Russian State Register (operating on an electronic online platform). There can be about twenty such requests per day; after a positive response the funds are unblocked and the transaction is completed. In the described risk assessment system, it independently (without human participation) requests codes (including readings from sensors of temperature, pressure, altitude, chemical composition of the air in the system, and even daily medical examination of employees), the frequency of such readings is determined by expert judgment and passed to the developer for the creation of an algorithm in the form of a protocol of the expert panel and the terms of reference for development.

It is worth mentioning that in the domestic economic science an important place is given to the analysis of risks in the sphere of development and real estate, and since no industrial project is created in isolation from the facility, it is necessary to take into account such risks analysed in the works of scientists as market risk, risk of planning approval, risk of inexperience of the developer, financial risk and risk of construction costs, as well as time risk [6].

CONCLUSIONS

In conclusion, the author would like to highlight the main novelty ideas of the Membrane Method of risk analysis developed by Denis Sezemin:

1. Distribution of risks by membrane layers. Each membrane layer is a stage (and its internal sub-stages) of the life cycle of the system; each risk presented in the membrane system is taken into account and considered a "sprout" that starts its way in the layer where it appears (or manifests itself) and can grow through all membrane layers, affecting the target indicators of the project.
2. The Membrane Method represents a unified system of risk analysis regardless of risk category and degree, based on three — quantitative, qualitative and parametric — methods.
3. By analogy with the medical method of contrast ultrasound (CT), the system allows using the colour contrast function to visually track certain types of risk, a more intense colour will indicate an area of increased risk.
4. It will allow visual and numerical data necessary for making management strategic and operational decisions to be displayed on the monitors of project managers at corporate headquarters.
5. Development of Membrane SDE software product on the basis of Sezyomin's Membrane Method of risk analysis will provide software independent from Microsoft and Apple systems, with the parallel task of creating software-specific libraries.
6. The created libraries (of errors and risks) should be published on a paid basis, including accessibility to foreign users under the condition of their multistage accreditation in accordance with legally defined procedures.
7. Automatic generation of periodic reports (monthly, quarterly, annually, at the end of a stage, as well as for the entire project).
8. The ability to generate any report in one click, taking into account the principle of priorities of managers and technical specialists in accordance with the specified scope of authority in the field of risk management of the company.
9. The system is configured in such a way that the notification about necessity of preparation by risk owners of the updated information on groups of risks for the monthly (quarterly) report is displayed automatically on a personal device of the risk owner and also the head of the company. Such a set of actions minimizes the risk of human factor influence on the execution of simple instructions for preparation of reporting in time (there will be no delay in execution). This is especially important for situations of new risk occurrence at any stage of the NPP project life cycle.
10. The software based on the Membrane Method of risk assessment by Sezemin makes it possible to apply a new concept of internal digital signature in the company, which will allow to transfer materials for studying and collect data confirming that the employee of the subdivision has read the document, in electronic form[5].
11. In the corners of the stacked layers of the membrane system are four target parameters of the project: economic parameters (costs, project budget, rate of return, net profit), time-related parameter — realization of the project within the terms

5 The costs of preparation, printing, collection of signature sheets and archiving in the physical sense of document flow should be estimated in monetary terms and compared with the costs of implementing electronic document flow using internal digital signature in the Corporation.

set by the feasibility study, qualitative parameters, and safety parameters of the project.

Therefore, the purpose of the research presented in the paper was achieved. The problem of risk identification and assessment at various stages of the NPP project life cycle was solved by applying the Membrane Method developed by the author.

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Мембранный метод в оценке организационной и технической надежности проекта строительства АЭС

Материалы представленной научно-исследовательской статьи основаны на анализе методических рекомендаций по повышению организационно-технической надежности проектируемых решений в условиях риска системы на этапе подготовки и основной фазе строительства крупных промышленных комплексов, таких как атомная электростанция. Системный анализ, проведенный автором представленной научно-исследовательской статьи, положен в основу методических рекомендаций по выбору рационального варианта плана организации работ при создании технически сложного промышленного объекта. Выводы, к которым приходит автор научно-исследовательской статьи, сделаны на основе разработки собственной имитационной модели анализа рисков с использованием современного подхода к применению автоматизированных систем календарного планирования производственных процессов реализации проектов АЭС, в том числе на международном межправительственном уровне.

Материалы представленной научно-исследовательской статьи содержат суть теоретических методик и практических рекомендаций по разработке и выбору рационального варианта организации работ на объекте строительства — атомной электростанции — на всех этапах жизненного цикла проекта. Процесс выбора наиболее рационального плана организации работ автор статьи предлагает базировать на сравнительном анализе результатов работы всех систем проекта, полученных на основе разработанной и внедренной имитационной модели под названием «мембранная модель» (здесь и далее — ММд) или «мембранный метод» (здесь и далее — ММт), парадигма которых (модели и метода) изложена ниже.

В статье представлены основные требования к техническому заданию для разработки российской технической наукой программного обеспечения для процессинговой обработки данных анализа рисков реализации проекта строительства проекта АЭС на каждом этапе жизненного цикла проекта.

Ключевые слова: *атомная электростанция, строительство АЭС, управление надежностью АЭС, управление строительными рисками АЭС, экономика строительства, промышленное строительство, многокритериальная оценка рисков, экономика предприятия, математическое моделирование, компьютерное моделирование рисков, автоматическая система управления*

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For citation: Sezemin D.E. Membrane method in assessment of organizational and technical reliability of NPP construction projects *Real Estate: Economics, Management*. 2023; 4:54-61.

Для цитирования: *Сезёмин Д.Е.* Membrane method in assessment of organizational andtechnical reliability of NPP construction projects // Недвижимость: экономика, управление. 2023. № 4. С. 54–61.

UDC 658.511

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Formation of risk factors for construction of nuclear power facilities in Latin American countries

The analysis of the development of the international nuclear power construction market makes it possible to identify and assess the problems of economic reliability and risks in the implementation of international projects of the State Corporation Rosatom. For many years, Rosatom has been consistently conducting international cooperation and support for various projects abroad, developing the company's and peaceful atom's competencies in other countries. The main directions in the field of international cooperation are the maintenance and implementation of nuclear power plants, as well as the development of a new promising area of international business development for the construction of nuclear research and technology centres. The article considers an example of the implementation of the centre for nuclear research and technology in the multinational state of Bolivia. The Centre for Nuclear Research and Technology is a complex innovative technical project that embodies a complex of nuclear technologies for the development of various fields at the state level (research, agricultural development, advanced training, medicine, expertise, etc.). The project is being implemented within the framework of an agreement between the Government of the Russian Federation and the Government of Bolivia, which also makes it possible to obtain a new contract in the Latin American market in the future. Examples of international cooperation in the field of international activities of the Rosatom are considered. An expert risk analysis of the project in Bolivia was carried out. Thus, in the future, several large pilot innovative high-tech projects will be implemented in Latin America, as well as further implementation of similar projects in other parts of the world (Africa and Asia).

Keywords: *Rosatom, nuclear construction industry, international cooperation, markets, risks, Centre for Nuclear Research and Technology*



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INTRODUCTION

The constant increase in scale and engineering complexity, the introduction of new advanced technologies, the complexity of solutions used in design and construction, the need to use modern building structures, materials and modern construction equipment, the high dynamism of the external environment of the project form the factor space of a construction company in the field of nuclear energy construction and nuclear technologies operating in the foreign market. This leads to an increase in the degree of risk and uncertainty in its economic activities [1, 2].

The main risk factors in foreign construction are the following groups of factors: international risks, socio-political risks, economic risks, regional risks, risks of an energy construction company, project risks.

International political and economic risks are unmanageable.

Regional risk takes into account the characteristics specific to a particular region.

The *risk of an energy construction company* is generated by the characteristics characteristic of the operation of a particular company and includes business risk and financial risk. Business risk is determined by the level of competitiveness of the company, the setting of marketing work. Financial risk is caused by the national financial policy and requires the creation of a special mechanism for rapid response to changes in the financial environment.

The *risk of a construction project* takes into account the specifics of a specific project, the implementation and maintenance of which is carried out by a construction company (General Contractor) [3, 4].

Rosatom unites more than 360 organizations and implements a huge number of the most diverse complex technical projects, including innovative ones in the Russian Federation and abroad (energy, medicine, science, education, transport, space, medicine, industry, military-industrial complex, etc.) (Table 1). Participation in such projects It implies a large number of emerging risks, which requires business entities to develop mechanisms for effective management of them (Fig. 1).

Many years of experience in the construction of nuclear power plants and acquired competencies, authority, resources, etc. allowed Rosatom not only to become one of the world leaders in the construction of nuclear power plants, but also to master new areas of activity that open up further prospects for further development. At the moment, in the field of nuclear energy use, Rosatom is one of the most in-demand companies in the world in terms of the number of high-power nuclear power plants of the latest generation 3+ being built simultaneously (Table 2)[1, 2] [5–9].

One of the key activities and priority goals of Rosatom is the development of global products to ensure effective import substitution processes within the country and occupy leading roles in international and global markets (Fig. 2).

1 Construction of most nuclear reactors is behind schedule. URL: https://www.economist.com/graphic-detail/2017/01/30/construction-of-most-nuclear-power-reactors-is-behind-schedule

2 Approaches to reducing costs for the construction of nuclear power facilities, Practical guide for stakeholders. Nuclear Energy Agency Organization for Economic Cooperation and Development. 2020; 33-34. URL: https://www.rosatom.ru/upload/docs/Unlocking_eductions_in_Construction_Costs_of_Nuclear.pdf (rus.).

Table 1. Rosatom State Corporation in the international energy market

A place in the international market	Indicator
No. 1 in the world	According to the portfolio of projects for the construction of nuclear power plants abroad (35 power units)
No. 1 in the world	Uranium enrichment (38 % of the global market)
The only one in the world	Nuclear Icebreaker Fleet
No. 2	By uranium reserves
No. 2	In terms of uranium production (15 % of the global market)
No. 3	In the nuclear fuel market (17 % of the global market)
19.7 %	The share of nuclear power plants in electricity generation in the Russian Federation
362	Organizations within the Corporation

Note: data from the public report of Rosatom State Corporation[3,4,5,6].

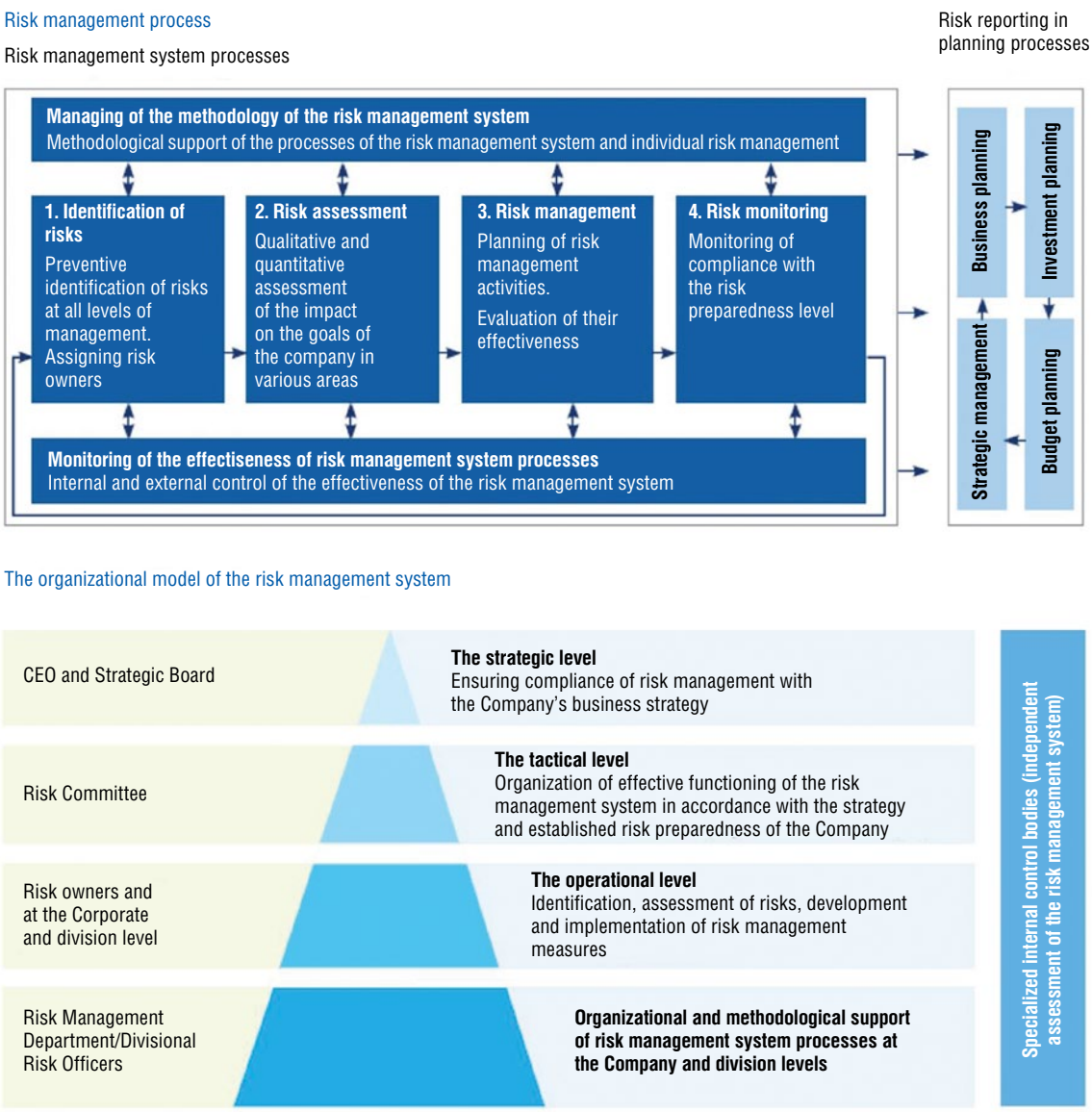


Fig. 1. Organizational model of RMS (risk management system) (data from the public report of Rosatom State Corporation[3,4,5,6])

3 Public report of Rosatom State Corporation for 2019.

4 Public report of Rosatom State Corporation for 2020.

5 Public report of Rosatom State Corporation for 2021.

6 Official website of the State Corporation Rosatom. URL: https://rosatom.ru/production/design/stroyashchiesya-aes

Table 2. Financial and economic results of the activities of Rosatom Group from year to year

Key financial indicators, trillion rubles			
Indicator	2019	2020	2021
Intangible assets	0.170	0.199	0.199
Assets	4.295	4.722	5.219
Revenue	1.151	1.207	1.447
Profitability indicators, %			
Return on sales by net profit (ROS)	11.55	13.00	13.39
Return on assets by net profit (ROA)	3.10	3.32	3.71
Return on equity by net profit (ROE)	5.10	5.58	6.34

Note: data from the public report of Rosatom State Corporation[3, 4, 5, 6].

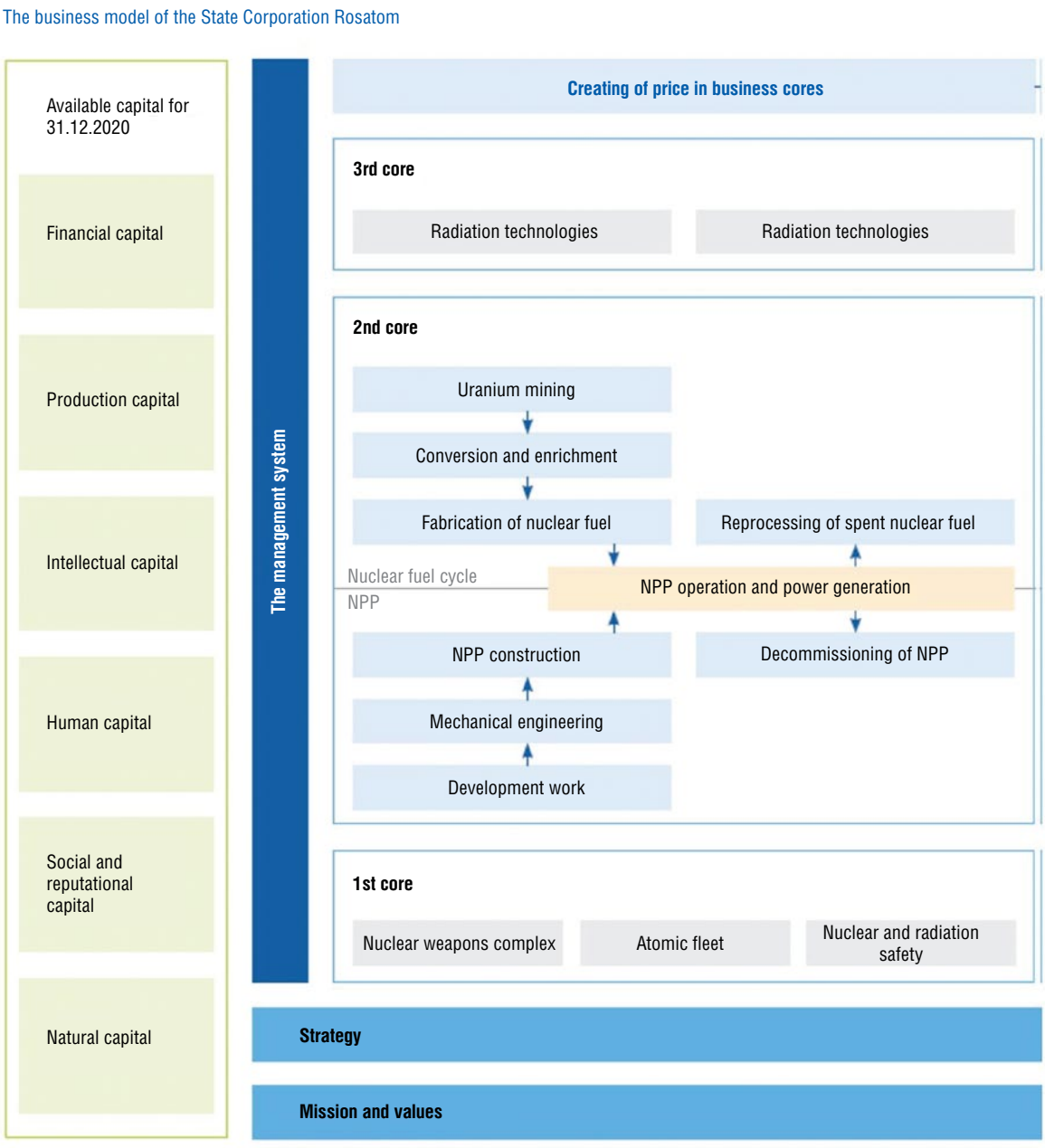


Fig. 2. Rosatom business model (data from the public report of Rosatom State Corporation[3, 4, 5, 6])

ANALYSIS OF NUCLEAR POWER CONSTRUCTION PROJECTS ABROAD

For many years, Rosatom has been consistently conducting international cooperation and support for various projects abroad, developing the company's and peaceful atom's competencies in other countries. The main directions in the field of international cooperation are the maintenance and implementation of nuclear power plants, as well as the development of a new promising direction for the development of international business for the construction of nuclear research and technology centres [1–4].

The most illustrative examples of interaction and international cooperation can be identified:

1. People's Republic of China (PRC) (cooperation, construction of nuclear power plants).

2. Close cooperation with the Atomic Energy Agency and the State Energy Administration of the People's Republic of China continued. The completion of the strategic package deal with Chinese partners has been ensured: general contracts for the construction of power units No. 7, 8 of the Tianwan NPP and power units No. 3, 4 of the Xudapu NPP have been signed. A dialogue has begun on expanding the agenda of bilateral cooperation in the field of nuclear energy. Such areas as the closure of the nuclear fuel cycle, the reprocessing of spent nuclear fuel and the deepening of cooperation in the field of science and technology, including basic science, were being worked out.

3. Republic of Belarus (construction, maintenance and commissioning of nuclear power plants).

4. During the construction and maintenance of the Belarusian NPP, cooperation was carried out with various ministries and state authorities on a wide range of issues related to the development of the regulatory framework in the field of atomic energy, safe and peaceful use of atomic energy.

5. Within the framework of the Treaty on the Creation of the Union State, a program for the development of nuclear energy in the Republic of Belarus has been defined.

6. India (cooperation, construction of nuclear power plants).

7. The support of various stages of the Kudankulam NPP project, the performance of various types of work and tasks continued: operation of power units, supply of technological and other equipment, development and transfer of documentation.

8. Preparations are underway for the possible implementation of a separate project for the construction of a new generation high-power nuclear power plant with a capacity of 1,200 MW.

9. The Republic of Bangladesh (cooperation, construction of nuclear power plants).

10. Support and implementation of the construction of the Ruppur NPP is carried out.

11. The multinational State of Bolivia (construction of the CNRT Centre for Nuclear Research and Technology with a research reactor).

Construction and installation works were carried out. The production, delivery and installation of the main and auxiliary equipment for the NPP was carried out. Staff training was conducted, including on the basis of the Rosatom Academy in the Russian Federation.

Negotiations are underway to identify promising opportunities for international cooperation in these regions, as well as neighboring regions and countries in Asia and Latin America:

1. Iran (cooperation, nuclear power plant operation).

2. Consultations and cooperation in the field of safe and peaceful use of nuclear energy, in accordance with the regulatory legislation of the Russian Federation and international obligations in the field of nuclear safety during operation of the Bushehr NPP.

3. Turkey.

4. Egypt.

5. Uzbekistan.

6. Hungary.

7. Finland.

In these countries, various types of work and consultations were carried out on the implementation of projects to prepare for the construction of nuclear power plants[1] [5–8].

THE NEW DIRECTION OF ROSATOM STATE CORPORATION IS AN INNOVATIVE PROJECT IN BOLIVIA

As an example of risk management abroad in the “novice” state, the consistent implementation of a pilot project in the multinational state of Bolivia will be considered: the Centre for Nuclear Research and Technology (CNRT) is a complex innovative technical project that embodies a complex of nuclear technologies for the development of various fields at the state level (research, agricultural development, raising the level of, medicine, expertise, etc.). The project is being implemented within the framework of the Agreement between the Government of the Russian Federation and the Government of Bolivia dated 06.03.2016, as well as the EPC contract dated 09.09.2017.

The centre consists of a research reactor, a multi-purpose radiation centre, a preclinical cyclotron radiopharmacological complex, and a laboratory of radiobiology and radioecology. This will allow you to solve several important tasks at once. It will contribute to increasing the pace of development of the national industry and agriculture, improving the level of health in Bolivia, improving the investment climate in the region and creating jobs for Bolivian citizens. It is planned that Bolivian specialists with specialized education will be employed at the research centre. In total, it is planned to create about 500 jobs for Bolivian citizens under the contract.

The reactor complex will allow for fundamental and applied research, which will provide additional tools for the development of various sectors of the economy, including the lithium industry.

Lithium is currently one of the most promising and critical elements for the development of energy storage systems and applications in a number of high-tech industries.

In June 2023, Rosatom State Corporation and the Bolivian state Company signed an agreement on the construction of an industrial complex for the extraction and production of lithium carbonate. This implies the creation in Bolivia (the country with the largest lithium reserves in the world) of a full-fledged scientific and production chain from the extraction of lithium raw materials to the production of a ready-made market product. This is a pilot foreign project of Rosatom State Corporation in the field of lithium production, while Rosatom will receive not only a profitable long-term contract, but also control over a part of the strategic resource, the demand for which only continues to grow. It is worth noting that a serious struggle was waged against companies from the USA, China, etc. for obtaining this contract. For example, Tesla and Lilac and Solutions participated in the tender from the USA.

Thus, in the future, several large pilot innovative high-tech projects will be implemented in Latin America, as well as further implementation of similar projects in other parts of the world (Africa and Asia).

RISK ANALYSIS OF THE PROJECT IN BOLIVIA

Analysis of risk events that could not be prevented by the Customer or Contractor. These are the risks associated with:

1. A political crisis (the resignation of the president, riots and looting in the country in 2019, which could lead to the loss of expensive equipment in warehouses and buildings of the centre).

2. The global COVID epidemic of 2019–2020 (inability to continue work and delivery of equipment).

3. The geopolitical situation (conducting a special military operation, subsequent sanctions against the Russian Federation and enterprises). The economic consequences associated with the refusal to cooperate with foreign suppliers, as a result of the disruption of supplies, the conclusion of new contracts, the selection of analogues, the change and increase in the cost of logistics, the need for redesign, etc. (Table 3).

These events can be classified as unmanageable risks. Nevertheless, the management and organizational decisions taken made it possible to minimize losses and continue the successful implementation of the project. Each of these risky events had a significant impact on the timing of the implementation of this project with a 3-year delay in delivery. This entailed additional financial costs (additional losses), but did not stop the construction and commissioning of the centre's facilities. In 2023, the commissioning of the centre's facilities and the active construction of the reactor complex will continue.

As part of the operation of the project in Bolivia, the author has established a list of risks, risk owners, conducted a risk assessment, and implemented measures to manage them.

The analysis of key risks affecting the financial stability of the company (General Contractor) was carried out on the basis of expert assessments received, in accordance with a previously defined list of identified risks.

For a qualitative assessment of the magnitude of the risks of the project in Bolivia, the Harrington scale was used (Table 4).

Table 3. Classification of risks during the construction of a nuclear research and technology centre in Bolivia

Risc	Risk assessment
International risk	4
Socio-political risk	4
Currency risk	3
Economic risk	3
Industry risk	3
Investment risk	2
Project risk	2
Reputational risk	2
Technogenic risk	2
Interest rate risk	2
Operational risk	2
Credit risk	2
The risk of industrial safety and labour protection	1
Liquidity risk	1
Risk in the field of services related to the nuclear fuel cycle	1
Environmental risk	1

Table 4. The Harrington scale

Qualitative characterization of probability	Quantitative characterization of probability in relation to risk components	Quantitative characterization of probability, %
Very low	1	0–20
Low	2	20–37
Average	3	37–63
High	4	63–80
Very high	5	80–100

ANALYSIS OF THE FINANCIAL STABILITY OF THE COMPANY (GENERAL CONTRACTOR)

The analysis of the financial stability of the enterprise (General Contractor) is carried out using an approach related to the assessment of the expediency of costs and is focused on the identification of potential risk areas.

In addition to unmanageable risks leading to cost overruns, excess costs may also arise due to the unanticipated or incorrectly predicted influence of the following manageable factors:

- incorrect design and further need for redesign;
- incorrect calculation of the cost;
- incorrect definition of the need for labor resources;
- incorrect forecasting of inflation.

Taking as a basis the list of key risks of the project, it is possible to further detail the risks and build a management and control system for each project individually, taking into account local characteristics (political, economic, cultural, logistical, etc.).

It is possible to minimize the capital at risk by breaking down the project allocation approval process into stages (areas). The approval stages should be linked to the design phases and based on additional information about the project as it is developed. At each stage of approval, having an analysis of the funds at risk, the investor can decide to terminate the investment.

It is proposed to determine three indicators of the financial stability of the company, in order to determine the degree of risk of financial resources.

Such indicators are:

- excess (+) or shortage (–) of own funds ($\pm E^c$);
- surplus (+) or shortage (–) of own, medium-term and long-term borrowed sources of reserves and costs ($\pm E^l$);
- surplus (+) or shortage (–) of the total value of the main sources for reserves and costs ($\pm E^n$).

The balance sheet model of the financial stability of the General Contractor has the following form:

$$F + Z + R^a = S^o + C^m + C^0 + R^p,$$

where F is fixed assets and investments;

Z — inventory and costs;

R^a — cash, short-term financial investments, accounts receivable and other assets;

S^o — a source of own funds;

C^m — medium-term, long-term loans and borrowings;

C^0 — loans not repaid on time;

R^p — accounts payable and borrowed funds.

To analyze the funds at risk, the overall financial condition of the company should be divided into five financial areas (Fig. 3):

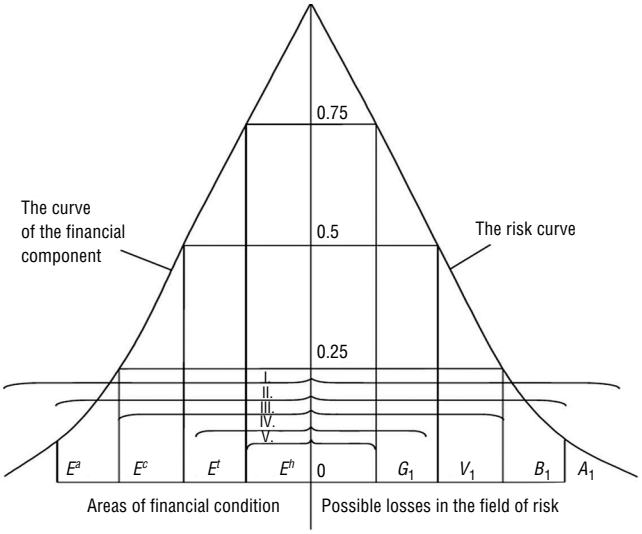


Fig. 3. The risk and financial condition curve [2, 3]

- area of absolute stability, when the minimum value of reserves and costs corresponds to a risk-free area;
- area of normal stability corresponds to the area of minimal risk when there is a normal amount of reserves and costs;
- area of unstable condition corresponds to the area of increased risk, when there is an excess amount of reserves and costs;
- area of critical condition corresponds to the area corresponds to the area of critical risk, when there is overstocking of finished products, low demand for products;
- area of catastrophic condition corresponds to the area of unacceptable risk, when there are excessive stocks and overstocking of finished products, and the developer is on the verge of bankruptcy [2, 3].

The calculation of three indicators of financial stability ($\pm E^c$, $\pm E^t$, $\pm E^h$) makes it possible to determine the degree of their stability for each area. Next, a three-component financial indicator will be used to identify the area of financial stability:

$$S = \{S(\pm E^c), S(\pm E^t), S(\pm E^h)\}.$$

The author of the article determined the values of financial stability indicators, as well as a three-component financial indicator for the project:

$$\pm E^c \geq 0;$$
$$\pm E^t \geq 0, S = (1, 1, 1);$$
$$\pm E^h \geq 0.$$

These indicators indicate the condition of the construction company, which corresponds to an absolutely stable or stable financial condition.

CONCLUSIONS

The developed classifier of risks of project implementation in foreign construction allows timely identification of negative risks in the construction process at the stages of implementation of an international project and monitoring the dynamics of changes in key risks of the project, timely management and further control to eliminate the negative consequences of risks.

The analysis of the main negative risks in the process of project implementation shows that the greatest risks are associated with the socio-political situation, financial and economic risks.

Indicators of financial and economic stability have been established using the example of an ongoing project in Bolivia.

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Формирование факторов риска строительства объектов атомной энергии в странах Латинской Америки

Анализ развития международного рынка атомно-энергетического строительства позволяет выявить и оценить проблематику экономической надежности и рисков при реализации международных проектов Государственной корпорации (ГК) Росатом. ГК Росатом на протяжении многих лет последовательно ведет международное сотрудничество и сопровождение различных проектов за рубежом, развитие компетенций компании и мирного атома в других странах. Основные направления в области международного сотрудничества: сопровождение и реализация АЭС, а также развитие нового перспективного направления развития международного бизнеса по сооружению центров ядерных исследований и технологий. В статье рассмотрен пример реализации центра ядерных исследований и технологий в многонациональном государстве Боливия. Центр ядерных исследований и технологий — сложный инновационный технический проект, воплотивший в себе комплекс ядерных технологий для развития на уровне государства самых разных областей (исследований, развития сельского хозяйства, повышения уровня медицины, экспертиз и др.). Проект реализуется в рамках Соглашения между Правительством Российской Федерации и Правительством Боливии. Это также позволяет в дальнейшем получить новый контракт на рынке стран Латинской Америки. Рассмотрены примеры международного сотрудничества по направлению международной деятельности

госкорпорации Росатом. Выполнен экспертный анализ рисков проекта в Боливии. Таким образом, в перспективе в Латинской Америке предстоит реализация нескольких крупных пилотных инновационных высокотехнологичных проектов, а также дальнейшая реализация аналогичных проектов в других частях мира (Африка и Азия).

Ключевые слова: *Росатом, атомная отрасль строительства, международное сотрудничество, рынки, риски, центр ядерных исследований и технологий*

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For citation: Gusev Yu.S. Formation of risk factors for construction of nuclear power facilities in Latin American countries. *Real Estate: Economics, Management*. 2023; 4:62-68.

Для цитирования: *Гусев Ю.С.* Formation of risk factors for construction of nuclear power facilities in Latin American countries // Недвижимость: экономика, управление. 2023. № 4. С. 62–68.



Москва. Успенская церковь с трапезной Новодевичьего монастыря. Рисунок, тушь перо

UDC 330

Zaytseva L.I.

Influence of judicial practice on the development of investment and construction sector and ensuring conflict–free project realization

In the current conditions of sanctions pressure and crisis phenomena, state regulation measures in the investment and construction sector should be aimed at preventing and eliminating contradictions and disputes between business entities, that is, the effectiveness of such measures must be assessed based on the ability to ensure conditions for conflict-free construction. At the same time, the concept of "conflict-free" does not mean the absence of disputes as such, but refers to the most constructive approaches to resolving disagreements, taking into account the interests of the participants in the relationship and the development priorities of the system as a whole. Of particular importance in achieving this goal is the activity of the judiciary in the field of forming a uniform judicial practice, focused on development priorities, as well as the application of judicial assistance technologies in the use of conciliation procedures in relation to construction disputes. Thus, the most significant recently developed positions relate to the extension of framework that is absent in the legislation, the interpretation of contract terms, the use of support measures and anti-sanction regulations, the peculiarities of bringing to responsibility for violation of urban planning standards and the consequences of non-compliance with mandatory requirements at the starting phase of the project. Analysis of approaches developed in judicial practice allows to identify risks associated with the implementation by public bodies (the prosecutor's office) of control and supervision functions. Assistance in the use of conciliation procedures, in turn, allows parties to use more flexible formats aimed at finding a mutually acceptable solution to a conflict situation within the court. At the same time, the problem of participation of public bodies in conciliation procedures remains relevant, significantly reducing their effectiveness.
Keywords: *judicial practice, conflict-free construction, government regulation measures, conciliation procedures, project mediation*



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The main criterion that determines the effectiveness of state regulation measures in the investment and construction sector is the ability to provide conditions for conflict-free construction. In the context of modern challenges, "absence of conflict" is transformed into the ability to resolve disagreements and eliminate contradictions in the most constructive manner, taking into account the interests of the participants in the relationship and the development priorities of the system as a whole. That is, this concept does not mean the absence of disputes and conflicts (their occurrence is inevitable, especially in difficult, complex realities), but the creation of mechanisms that help to eliminate the destructive element, ensuring the most effective way out of a conflict situation (if it arises) and, as the option of highest priority — preventing escalation of contradictions between disputing parties [1].

One of the conditions of conflict-free construction is the practice-oriented activities of the judiciary, which is formed taking into account the sectoral approach which performs, among other things, a regulatory function. In addition to basically resolving disputes, the courts form approaches set out in judicial acts (especially district courts and the Supreme Court of the Russian Federation), which perform the functions of contradictions elimination in current regulations (regarding specific usage of norms in particular legal relations) and filling in gaps, including extension of framework (notions, principles etc.).

As an example, we can refer to the concept of "construction in progress", which is not defined in legal acts, but at the same time its features are indicated in the resolution of the Plenum of the Supreme Court of the Russian Federation dated June 23, 2015 No. 25 "On the application by courts of certain provisions of Section I of Part One of the Civil Code of the Russian Federation". In accordance with section 38, when resolving issues of recognizing as an immovable thing of an object being legally under construction (an object of construction in progress), it is necessary to establish that at least the groundwork construction or similar works have been fully completed (clause 1 of Article 130 of the Civil Code of the Russian Federation). Paving of a land plot that does not meet the characteristics of a structure is part of it and cannot be recognized as an independent immovable thing (clause 1 of Article 133 of the Civil Code of the Russian Federation)[1].

In addition, currently judicial practice is being actively developed on disputes related to use of anti-sanction measures of support to the construction industry, in particular with the use of moratorium on the imposition of financial sanctions as an anti-crisis tool aimed at minimizing the consequences of the sanctions regime and ensuring the stability of the state's economy. In one of the cases (No. A40-78279/2022), it was concluded that such an instrument is subject to application to both monetary and non-monetary obligations, namely, the transfer of an object

1 On the application by courts of certain provisions of Section I. Part One of the Civil Code of the Russian Federation : Resolutions of the Plenum of the Supreme Court of the Russian Federation dated June 23, 2015 No. 25. URL: https://vsrf.ru/documents/own/8435/ (accessed: 10.30.2023).

in proper condition and on time. Let us recall that this moratorium was provided for by Decree of the Government of the Russian Federation dated March 28, 2022 No. 497 and was valid until October 1st, 2022[2].

Taking into account the large-scale regulation in the field of crisis management, it is possible to predict a significant number of disputes that will arise in connection with the use of anti-sanctions measures. In this regard, the approaches of the judiciary will serve as an important guide in practical activities.

The practice-influencing approaches which have been developed in the last few years by the Supreme Court of the Russian Federation in relation to urban planning activities include.

Regarding contracts related structures:

- the conclusion that the identification of real legal nature of a contract should be based on the actual type of obligations and the characteristics of certain types of contracts provided for by law, regardless of the title indicated by parties, their description, as well as the specification of performance method. Interpretation of contractual terms, which may lead to the extraction of unjustified advantage by one of the parties due to the ambiguity of the wording proposed by it, is unacceptable. If there is a valid contract, the date of transfer of advance payment for the completion of work is not the moment when the limitation period begins to run;
- if the contract provides for the right to withhold penalties and other sums due to the contractor, it is necessary for the court to establish whether there is a delay in fulfilling obligations in disputes regarding the collection of funds for work performed. The pre-court claim procedure of dispute resolution is aimed at its prompt resolution and serves as an additional guarantee for protection of rights, and therefore the deadline for filing a suit established by contractual terms is not preclusive and does not entail any consequences for the parties;
- when a contract specifies the maximum degree of a contractor's liability, the amount of penalty for violating the deadlines for completing work cannot exceed such degree, taking into account that the procedure for determining the amount of the penalty agreed upon by the parties does not conflict with any express legislative prohibition and does not violate the essence of legislative regulation of relations under construction contract, or particularly significant interests protected by law and does not lead to a gross violation of parties balance of interests;
- the presence of an supplemental agreement on changing the timing of work performance does not exclude the possibility of terminating the contract by the customer on the ground of violating deadlines by the contractor before conclusion of supplemental agreement, if these violations were systematic.

Regarding prosecution for violation of urban planning regulations:

- on application of Article 9.5 of the Code of Administrative Offenses of the Russian Federation (violation of the established procedure for construction, reconstruction, major repairs of a capital construction project, its commissioning): the presence of a judicially confirmed ownership of a real-estate object does not grant the right to operate it after reconstruction without obtaining permission to put the facility into operation in the prescribed manner;
- prosecution under Part 1 of Article 9.4 of the Code of Administrative Offenses of the Russian Federation (violation of mandatory requirements in the field of construction and use of building materials) does not exclude the accrual of a penalty under the contract for similar violations;
- the possibility of being held accountable under Article 6.7 of the Code of Administrative Offenses of Moscow (violation of the permitted use of a land plot) in the event of the acquisition of an object after its reconstruction, which led to a violation of the requirements and restrictions on the use of the land plot.

It seems that the disputes with the highest degree of conflict are those that have the greatest relevance for jurisprudence, which have the effect of "leveled value" and retroactive effect: when, despite the prospects of the project and receipt of all necessary approvals, proceedings are initiated leading to the freezing of the project and further demolition of the already constructed objects (for example, recognition of construction authorizations as illegal) by the initiative of regulatory authorities. At the same time, the rights of final buyers investing in future properties at the early stages are significantly violated [2].

One should not forget that the lack of initial planning permits in itself cannot serve as a basis for the demolition of an unauthorized construction site. The determining factor influencing the possibility of legalizing a building is compliance with safety requirements (no threat to the life and health of citizens) and the possibility of preserving the building (or restoring it to its original form). This is precisely the logic contained in the draft resolution of the Plenum of the Supreme Court of the Russian Federation "On some issues arising in judicial practice when applying the rules on unauthorized construction".

The analysis of practice showed the presence of the following risks associated with the implementation by public bodies (prosecutor's office) of control and supervision functions:

- challenging a building permit after a significant period of time after commencement of construction;
- the possibility of taking by the court of interim measures in the form of a ban on construction work;
- recovery as the revenue into the budget of the damage related to inability to use the land due to its buildings, as well as due to damage to the soil layer during construction;
- foreclosure in favour of the Russian Federation on unfinished construction projects;
- invalidation of the lease agreement for a land plot, and, as a consequence, the need to vacate the land plot (in connection with the violation of the legally protected interests of the Russian Federation and of indefinite number of persons, for example, in connection with a change in the type of permitted use of the land and the conclusion of an additional agreement to the lease agreement, which may be regarded as granting a land plot for construction purposes, bypassing the procedure established by land legislation, taking into account paragraphs 2, 3 of the Review of the practice of consideration by courts of judicial cases related to changes in the type of permitted use of a land plot, approved by the Presidium of the Supreme Court of the Russian Federation on November 14, 2018, determination of the Judicial Collegium on economic disputes of the Supreme Court of the Russian Federation dated January 23, 2020 No. 305-ES19-18488[3];
- non-application of the statute of limitations, since a transaction for the transfer of a land plot for rent may be considered

2 On the introduction of a moratorium on the initiation of bankruptcy cases on applications submitted by creditors : Decree of the Government of the Russian Federation of March 28, 2022 No. 497 (as amended on July 13, 2022). URL: http://publication.pravo.gov.ru/Document/View/0001202204010040 (accessed: 30.10.2023).

3 Review of the practice of courts considering cases related to changes in the type of permitted use of a land plot : approved by the Presidium of the Supreme Court of the Russian Federation on November 14, 2018. URL: https://www.consultant.ru/document/cons_doc_LAW_311024/ (accessed: 30.10.2023).

void (in accordance with paragraph 71 of the resolution of the Plenum of the Supreme Court of the Russian Federation dated June 23, 2015 No. 25 "On the application by courts of certain provisions of Section I of Part One of the Civil Code of the Russian Federation" a void transaction, unlike a contested transaction, is invalid regardless of whether it is recognized as such by the court [1]. The defendant's objection that the plaintiff's claim is based on a void transaction is assessed by the court on its merits, regardless of the expiration of limitation period for declaring this transaction invalid);

- inability to compensate losses incurred due to the freezing of a construction project if the construction company is found to be guilty of violating land, town planning, and environmental legislation. In such cases, the courts indicate that, with due care and prudence, the person should have foreseen negative consequences associated, for example, with a change in the type of permitted use in violation of the requirements of land legislation. Likewise, a person could not have been unaware of the prohibition by current legislation from constructing real estate in a certain area without conducting a state environmental assessment of project documentation and conducting archaeological field work.

It should be noted that in the event of an illegal refusal to issue permits by the authorized body, the judicial practice of collecting losses caused by such actions has not currently been developed:

- occurrence of direct losses due to liability to final buyers (investors) [3];
- finally, huge reputational costs, which question the possibility of further successful implementation of other projects. Moreover, there is a high probability of bankruptcy of the construction company due to the losses indicated above, including lost profits [4].

In addition, litigation on the nationalization of enterprises has become a trend over the past few years. Since 2020, the number of cases in which the Prosecutor General's Office challenges the results of privatization in the 90s has increased 8 times. In 2023, arbitration courts settled a record number of such disputes [5]. Moreover, in a number of cases, the initiation of the process of "renationalization" of strategic assets occurs due to the emergence of a conflict situation (as in the case of the "Bashkir Soda Company", the case became widely known due to large-scale protests by environmental activists).

Taking into account the identified aspects and features of the formation of judicial practice, the need for development and implementation of out-of-court methods of dispute resolution that can take into account the characteristics of a specific project becomes obvious [6]. We are talking, first of all, about *project mediation*, as well as *specialized dispute resolution commissions* (*Dispute Review Board (DRB)*). At the same time, members of such commissions should have experience not only in the field of dispute resolution, but also in the specific area of the project [7]. Resolution of disagreements with the participation of a commission is one of the most essential conditions of the contract (analogous to a mediation clause), which serves as a certain guarantee for the parties. A distinctive feature of DRB from other alternative methods of dispute resolution is the formation of the body at the early stages of project implementation, that is, before a dispute arises. Members of the commission are direct participants in the project, carry out a kind of monitoring of its various stages, prevent the emergence of disagreements and, in case of escalation of contradictions, directly resolve the dispute [8].

However, "alternativeness", as such, does not mean that having initiated a dispute in court, the parties are deprived of the opportunity to use more flexible procedures aimed at finding a mutually acceptable way out of the conflict situation [9]. Thus, within the courts there is an option that allows to postpone the consideration of the case and try to conclude a mediation (settlement) agreement on the basis of the so-called "rooms for conciliation procedures". Moreover, this possibility remains in courts of various levels and has an important impact on the formation of a favorable business climate [10].

Thus, in addition to providing judicial practice that contributes to the sustainable development of construction industry, the task of the judiciary is to apply *technologies of judicial assistance in the use of conciliation procedures in relation to construction disputes*. The analysis showed that the vast majority of cases in which the mediation procedure was initiated in reconciliation rooms related specifically to the implementation of investment and construction projects. In all cases, the judges analyzed disputes from the point of view of *mediation potentials* (the main criterion for the possibility of concluding a settlement agreement) and explained the advantages of using alternative methods, such as mediation [11]. Cooperation with the College of Mediators at the Chamber of Commerce and Industry of the Russian Federation was also constructive in order to provide qualified services for carrying out this procedure[4].

At the same time, the problem of involvement and participation of public bodies in conciliation procedures remains unresolved to date. Lack of awareness of the effectiveness of such procedures leads to the impossibility of fully unlock its potential and, as a result, leveling out the positive effect of collaborative models of interaction among project participants.

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Влияние судебной практики на развитие инвестиционно-строительной деятельности и обеспечение бесконфликтной реализации проектов

В сложившихся условиях санкционного давления и кризисных явлений меры государственного регулирования инвестиционно-строительной сферы должны быть нацелены на предотвращение и устранение противоречий и споров между хозяйствующими субъектами, т.е. действенность таких мер подлежит оценке исходя из способности обеспечить условия бесконфликтного строительства. При этом понятие «бесконфликтность» не означает отсутствие споров, как таковых, а относится к наиболее конструктивным подходам к урегулированию разногласий с учетом интересов участников отношений и приоритетов развития системы в целом. Особое значение в реализации указанной цели имеет деятельность судебных органов в области формирования единообразной ориентированной на приоритеты развития отрасли судебной практики, а также применения технологий судебного содействия в использовании примирительных процедур в отношении строительных споров. Так, наиболее значимые позиции, выработанные в последнее время, относятся к дополнению понятийного аппарата, отсутствующего в законодательстве, толкованию условий контрактов, применению мер поддержки и антисанкционного регулирования, особенностям привлечения к ответственности за нарушение градостроительных норм и последствиям несоблюдения обязательных требований на стартовой фазе реализации проекта. Анализ подходов, выработанных в судебной практике, позволяет выявить риски, связанные с реализацией публичными органами (прокуратурой) функций по контролю и надзору. Содействие в использовании примирительных процедур, в свою очередь, позволяет сторонам использовать более гибкие форматы, нацеленные на поиск взаимоприемлемого выхода из конфликтной ситуации, в рамках суда. Вместе с тем актуальной остается проблема участия публичных органов в примирительных процедурах, существенно снижающая их эффективность.

Ключевые слова: *судебная практика, бесконфликтное строительство, меры государственного регулирования, примирительные процедуры, проектная медиация*

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For citation: Zaytseva L.I. Influence of judicial practice on the development of investment and construction sector and ensuring conflict-free project realization. *Real Estate: Economics, Management*. 2023; 4:69-72.

Для цитирования: *Зайцева Л.И.* Influence of judicial practice on the development of investment and construction sector and ensuring conflict-free project realization // Недвижимость: экономика, управление. 2023. № 4. С. 69–72.

UDC 343.977

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Methodology of research of design documentation for construction in order to assess its compliance with the requirements of special rules in the production of judicial construction and technical expertise (in the order of discussion)

The article proposes a methodology of research of design documentation intended for construction, reconstruction and capital repairs (hereinafter referred to as construction) of capital construction facilities within the framework of construction and technical forensic examinations, taking into account the regularly changing requirements of urban planning legislation. The list of issues resolved within the framework of these examinations is given. The objects of research are identified, the purpose of which is to resolve issues of compliance of project documentation with the requirements of special rules[1]. The principal differences and exceptional provisions are indicated when conducting construction and technical forensic examinations of project documentation from the state examination of project documentation conducted by a state body within the framework of Article 49 of the Urban Planning Code of the Russian Federation (UPC of the Russian Federation). A list of regulatory requirements for project documentation is formed, which are presented in various time by documents of urban planning legislation and national standards. The stages of conducting research on the composition and content of project documentation, to which different requirements are imposed in different time, are considered. The proposed methodology for conducting research in relation to project documentation is intended for forensic experts conducting research within the framework of forensic examinations on the materials of criminal cases or materials of procedural checks appointed by the investigative body. Particular cases of application of regulatory requirements depending on the time of development of project documentation or other documents establishing the legal status of project documentation are considered.

Keywords: *project documentation, buildings and structures, judicial expertise, construction, regulatory requirements, conformity assessment*



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INTRODUCTION

Forensic expertise is of great importance in the investigation of criminal cases and their subsequent judicial review. The theoretical and organizational foundations of forensic examination, the procedure for the appointment and production of judicial examinations are currently sufficiently elaborated by the criminal procedure legislation and are considered in detail in [1], as well as in numerous methodological and reference manuals. At the same time, construction and technical expertise as a kind of forensic expertise, in comparison with other types of expertise, is considered quite young. It can rightfully be said that this kind of expertise is still at the stage of its formation and development. General organizational approaches, methodological and legal bases for the appointment and production of judicial construction and technical expertise (JCTE) were formed and consolidated in numerous works by A.Yu. Butyrin [2, 3], practical manuals, for example, in the work of O.S. Vershinina [4]. However, it is worth noting that in the sources known to the authors, much attention is paid to the issues of studying the construction sites themselves within the framework of the JCTE, in isolation from their design documentation, and issues related to the study of design documentation for their construction, as well as methodological approaches to resolving these issues, are not given due attention, or are purely illustrative. But it is in the design documentation that the reliability of the future construction facility is laid down, and subsequently, in accordance with this design documentation, the condition of the construction facility is maintained throughout its entire life cycle.

The need for the appointment of a forensic examination to study the design documentation for construction is primarily due to the discovery during the investigation of the criminal case of the facts (circumstances) of the commission of a crime, which may presumably be causally related to the non-compliance of the design documentation with the requirements of special rules. Such facts (circumstances) may be, for example: defects (damages) of load bearing and enclosing structures of buildings (structures), which indicate the presence of danger to the life and health of citizens; non-compliance of indoor microclimate parameters with sanitary requirements; the collapse of a building or a separate part of it; the impossibility or limited possibility of using project documentation for the development of working documentation and construction

1 Under the requirements of special rules in the context under consideration, the authors understand the requirements of urban planning legislation and legislation on technical regulation.

of the facility, as well as other facts indicating that the crime could have been committed with intentional or negligent actions of persons during the preparation of project documentation, examination of project documentation, issuance of construction permits and (or) commissioning the operation of capital construction facilities, and so on.

It is important to note that in the production of JCTE, forensic construction experts do not replace or duplicate the bodies of state (or non-state) expertise of project documentation, which carry out professional activities within the framework of Article 49 of the Urban Planning Code of the Russian Federation (UPC of the Russian Federation) [5] and the Decree of the Government of the Russian Federation[2]. The main and significant difference in the approach to the production of forensic expertise is that a forensic expert carries out his professional activities within the framework of Article 57 of the Code of Criminal Procedure[3] of the Russian Federation. At the same time, they (the forensic expert) do not substitute the examination of draft documentation, which is provided for by urban planning legislation (Part 6 of Article 49 of the UPC of the Russian Federation [5]), with a forensic examination.

RESOLVED ISSUES

Based on the circumstances of the criminal case, among the main issues raised by the investigation or the court for the permission of an expert, the following questions can be attributed:

1. Did the project documentation comply with the requirements of special rules for the composition of sections of the project documentation and the composition of the content of these sections as of the date[4]?

2. Did the project documentation comply with the requirements imposed on it by the state contract (or other contract, agreement) in separate paragraphs (determined by the results of consultations with an expert) and appendices thereto (terms of reference for design, calendar plan, etc.; if necessary, determined by the results of consultations with an expert)?

3. Did the project documentation comply with the requirements of special rules in certain parts of its sections (determined based on the results of consultations with an expert) in force on the date of issuance of the urban development plan of the land plot?

This list of issues is usually not exhaustive. Thus, for the permission of a forensic expert, in the presence of characteristic signs indirectly indicating the presence of inconsistencies, for example, the presence of progressive defects and damages, deformations and rolls of capital construction facilities, questions may be raised about the compliance of specific sections of the project documentation with the requirements of special rules:

4. Is there a causal relationship between the appearance of defects (damages) in the load bearing and enclosing structures of a building (structure) with the non-compliance of the design documentation with the requirements of special rules?

5. Is the collapse of the building causally related to the non-compliance of the design documentation with the requirements of special rules?

We have considered the procedure and methodology for resolving issues 4 and 5 using specific examples in the methodological recommendations [6], as well as articles [7–9]. When resolving the above issues within the framework of the JCTE, in order to avoid expert error, it is extremely important to correctly interpret the results of calculations of load bearing building structures and verify computer models for the correctness of accepted calculation schemes when it is necessary to establish, for example, the cause of destruction of an object or part of it, as indicated by the authors of the work [10]. However, these issues are not considered in this article, as this is the subject of a separate study.

OBJECTS OF RESEARCH

The objects of research are project documents in paper or electronic form (scanned copies of project documents), as well as calculation results substantiating technical solutions adopted in project documents on paper and(or) electronic media.

Since changes may be made to it during the development of project documentation and at the construction stage, as a result, several versions of project documentation sets are formed. These changes must be registered by the design organization in accordance with Section 7 of the State Standard of the Russian Federation 21.1101[5, 6]. Regardless of the fact that the designer fulfilled the regulatory requirements and registered the changes made in accordance with the established procedure, different versions of the developed kits for which construction is carried out may be available to different participants in urban planning activities (the designer, the developer (technical customer), the authority that issued the construction permit, the general contractor, etc.). In this regard, the investigation may also have at its disposal different versions of sets of project documentation in relation to one capital construction object under consideration.

Therefore, before the appointment of a forensic examination of the project documentation, depending on the circumstances of the case, the investigator must determine which version of the project documentation should be sent for research. At this stage of the preparation of materials, it is recommended to involve a knowledgeable person with special knowledge in the field of construction design. A knowledgeable person may be a representative of a design or research organization in the field of construction.

The final version of the project documentation, the study of which is to be performed as part of the forensic examination, should be considered the version of the project documentation that meets the following requirements:

- has the latest version (with all changes);
- approved by the developer (technical customer) by affixing the appropriate stamp “for the production of works” or approved by an official letter from the technical customer, in accordance with Part 15 of Article 48 of the UPC of the Russian

2 On the procedure for organizing and conducting State Expertise of project documentation and engineering survey results : Decree of the Government of the Russian Federation No. 145 dated 03.05.2007.

3 Criminal Procedure Code of the Russian Federation No. 174-FL dated 12.18.2001.

4 Depending on the circumstances of the case, the date as of which it is required to conduct a study of the project documentation should be agreed upon as part of the preliminary consultation of the investigator before the appointment of the examination and unambiguously determined by the investigator in the matter being put to the expert's permission.

5 The State Standard of the Russian Federation 21.1101–2013. Basic requirements for design and working documentation (approved and put into effect by Russtandart Order No. 156-st dated 11.06.2013) — effective period from 01.01.2014 to 01.01.2021.

6 The State Standard of the Russian Federation 21.1101–2009. The system of design documentation for construction. Basic requirements for design and working documentation (approved by the Order of Rustech Regulation No. 525-st dated 11.30.2009) — the period of validity is from 03.01.2010 to 01.01.2014.

Federation [5], including in cases provided for in Part 15.2 and Part 15.3 of Article 48 of the UPC of the Russian Federation [5];

- has a positive conclusion of the expert examination of the project documentation (except for the cases provided for in part 2 of Article 49 of the UPC of the Russian Federation [5] in relation to capital construction projects, when the expert examination of the project documentation is not carried out).

When studying, within the framework of forensic examinations (procedural checks), project documentation for facilities financed with the involvement of funds from the budgets of the budgetary system of the Russian Federation for compliance with the specified documentation with the requirements imposed on it, a necessary and sufficient criterion for the final version of the project documentation is the presence of a positive conclusion of the expert examination of the project documentation[7].

If there is no positive conclusion of the state expertise on the above-mentioned project documentation (for example, the project documentation has not passed the state expertise or has a negative conclusion of the state expertise), then within the framework of the forensic examination conducted in relation to such documentation, this indicates a direct discrepancy between the project documentation and the requirements of special rules.

In addition, in the above context, it seems unacceptable to send several versions of sets of project documentation for forensic examination in relation to one capital construction facility and entrust the expert with the choice of the version of the set on which the study should be conducted. It is possible to consolidate the fact according to which version of the project documentation the construction was carried out on the basis of an inspection of the scene with the involvement of a knowledgeable person as a specialist.

THE LEGAL STATUS OF THE PROJECT DOCUMENTATION

The design documentation is the main document that establishes requirements for the safety of buildings (structures), as well as for their parameters and characteristics.

The project documentation is a legally significant document and has the appropriate legal force on the basis of urban planning legislation [5, 12] and legislation on technical regulation [13]. The working documentation is developed on the basis of the project documentation. The preparation of project documentation and working documentation can be carried out simultaneously[8] [5].

Due to the fact that the use of working documentation in construction without design documentation is not allowed, within the framework of forensic examinations, working documentation is considered only if there is design documentation in accordance with which it was developed.

The project documentation acquires legal force if it is prepared and executed in accordance with the requirements of urban planning legislation and has a positive conclusion of the state (non-state) expertise of the project documentation (except for the cases provided for in Part 2 of Article 49 of UPC of the Russian Federation [5]).

During the study within the framework of the appointed forensic examination, it can be established that the project documentation, which received a positive conclusion from the state (non-state) examination, was amended after it was received. Changes that were made to the project documentation after receiving a positive expert opinion are considered insignificant and do not require repeated examination[9] [5] if such changes are simultaneously [11]:

- do not affect the load bearing building structures of the capital construction facility, except for the replacement of individual elements of such structures with analogous or other elements that improve the performance of such structures;
- do not entail a change in the class, category and (or) the originally established indicators of the functioning of linear objects;
- do not lead to violations of the requirements of technical regulations, sanitary and epidemiological requirements, requirements in the field of environmental protection, requirements of state protection of cultural heritage sites, requirements for the safe use of nuclear energy, industrial safety requirements, requirements for ensuring the reliability and safety of electric power systems and electric power facilities, requirements for anti-terrorist protection of the facility;
- correspond to the task of the developer or technical customer for the design, as well as the results of engineering surveys;
- correspond to the cost of construction (reconstruction) of a capital construction facility carried out at the expense of the budgets of the budgetary system of the Russian Federation, established in the decision on the provision of budgetary allocations for capital investments adopted in respect of a capital construction facility of state (municipal) ownership in accordance with the established procedure.

Thus, if, during the study of the project documentation within the framework of the JCTE, non-compliance with one or more of the above points was established, then this is the basis for concluding that the project documentation does not comply with the established regulatory requirements.

In the design documentation, the safety of the building (structure) must be justified by calculation[10]. The design justification of constructive solutions is an integral part of Section 4 “Constructive solutions”. In order to conduct a forensic construction and technical examination, the design justification of the design solutions of the object under study is requested from the investigative body at the request of an expert. If there are characteristic signs of damage to the object, indirectly indicating that Section 4 “Constructive solutions” does not comply with the requirements of special rules, this section should be examined for compliance with the requirements of Federal Law No. 384-FL[11] dated December 30, 2009 “Technical Regulations on the Safety of Buildings and Structures” [12]. At the same time, if the design justification of the design decisions is not available to the investigative body, the expert must independently verify the compliance of the design documentation with

7 What is defined by Part 3 of Article 110.2 of Federal Law No. 44-FL dated 04.05.2013 “On the contract system in the field of procurement of goods, works, services for state and municipal needs” (with amendments and additions, intro. effective from 01.01.2023).

8 Part 2.1 of Article 48 of UPC of the Russian Federation.

9 It is provided for in Part 3.8 of Article 49 of UPC of the Russian Federation.

10 An explanatory note containing the calculated justification of constructive solutions is stored in the archive of the project organization (the author of the project), this document is not provided to the customer.

11 Further Federal Law No. 384-FL.

the requirements of Federal Law No. 384-FL [12]. If the expert does not have competence in narrow areas of research that require resolution within the framework of the issues raised by the investigation, the expert is obliged to file a petition for the involvement of a person with special knowledge in this area of research.

The main requirements for project documentation, effective at various periods of time, are set out in the following normative documents [5, 14]: national standards and codes of rules (parts of such standards and codes of rules), as a result of which compliance with the requirements of Federal Law No. 384-FL, approved by documents[12] [15–18]; documents defining the requirements for graphic and textual materials [19]; national standards and codes of practice (parts of such standards and codes of practice), as a result of which compliance with the requirements of Federal Law No. 384-FL approved by Orders is ensured on a voluntary basis [20–23].

During each study, the expert forms a list of regulatory documents, depending on the circumstances of the criminal case in relation to the design documentation of the object under study. As of the date set in the question submitted for the expert's permission, it is necessary to select the valid versions of documents from the lists of national standards and sets of rules, as a result of which, both on a mandatory and voluntary basis, compliance with the requirements of Federal Law No. 384-FL is ensured [12].

In particular cases, it is necessary to use documents and their editions that establish regulatory requirements for a capital construction facility on the date of legally significant actions in the process of preparing project documentation (for example: the date of approval of the design assignment, the date of issuance of a construction permit, etc.). Following Part 5.2 of Article 49 of UPC of the Russian Federation [5], the study The design documentation can be performed for compliance with the regulatory requirements in force on the date of issue of the urban development plan of the land plot, on the basis of which such design documentation was prepared, in the same way as it is performed during the production of state expertise of project documentation.

According to Part 1 of Article 46 of the Federal Law "On Technical Regulation" No. 184-FL [13], before the entry into force of the relevant technical regulations, the requirements for products and related requirements for design processes (including surveys), production, construction are subject to mandatory execution only in the part corresponding to the goals of protecting the life or health of citizens, property of individuals or legal entities, state or municipal property. Within the framework of forensic examinations, this provision is understood as follows: if the design documentation does not contain other justifications for ensuring the safety of construction (for example, mechanical safety), such as the results of research, calculations and (or) tests (performed using certified or otherwise approved methods), then the regulations governing the methods of ensuring the safety of construction facilities from lists of documents approved by orders [20–23] in the field of standardization, as a result of which compliance with the requirements of Federal Law No. 384-FL is ensured on a voluntary basis [12], are considered mandatory.

FINAL PROVISIONS

The main provisions set out in this article have been tested in the course of judicial construction and technical examinations conducted at the Forensic Expert Center of the Investigative Committee of the Russian Federation as part of research on project documentation in criminal cases. Based on the results of this work, a methodology is proposed that is applicable to conducting research on project documentation intended for the construction, reconstruction and overhaul of capital construction facilities within the framework of the JCTE, and the objects of research are identified. The principal differences between the forensic examination and the state examination of project documentation conducted by a state body within the framework of Article 49 of UPC of the Russian Federation [5]. The proposed methodology for conducting research within the framework of forensic examinations does not contradict the provisions of urban planning legislation [5] and legislation "On Technical Regulation" [13].

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Методика исследования проектной документации для строительства на предмет оценки ее соответствия требованиям специальных правил при производстве судебных строительно-технических экспертиз (в порядке обсуждения)

В статье предложена методика проведения исследований проектной документации, предназначенной для осуществления строительства, реконструкции и капитального ремонта (далее строительства) объектов капитального строительства в рамках строительно-технических судебных экспертиз с учетом регулярно изменяющихся требований градостроительного законодательства. Приведен перечень разрешаемых в рамках указанных экспертиз вопросов. Определены объекты исследования, целью которого является разрешение вопросов соответствия проектной документации требованиям специальных правил[1]. Указаны принципиальные отличия и исключительные положения при проведении строительно-технических судебных экспертиз проектной документации от государственной экспертизы проектной документации, проводимой государственным органом в рамках статьи 49 Градостроительного кодекса Российской Федерации. Сформирован перечень нормативных требований в отношении проектной документации, предъявляемых в различные временные периоды документами градостроительного законодательства и национальными стандартами. Рассмотрены этапы проведения исследований состава и содержания проектной документации, к которой в различные временные периоды предъявляются различные требования. Предлагаемая методика проведения исследований в отношении проектной документации предназначена для судебных экспертов, проводящих исследования в рамках судебных экспертиз по материалам уголовных дел или материалам процессуальных проверок, назначаемых следственным органом. Рассмотрены частные случаи применения нормативных требований в зависимости от временного периода разработки проектной документации или иных документов, устанавливающих правовой статус проектной документации.

Ключевые слова: *проектная документация, здания и сооружения, судебная экспертиза, строительство, нормативные требования, оценка соответствия*

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For citation: Balabin Yu.A., Kokovin A.Yu., Novozhilov V.A. Methodology of research of design documentation for construction in order to assess its compliance with the requirements of special rules in the production of judicial construction and technical expertise (in the order of discussion). *Real Estate: Economics, Management*. 2023; 4:73-78.

Для цитирования: *Балабин Ю.А., Коковин А.Ю., Новожилов В.А.* Methodology of research of design documentation for construction in order to assess its compliance with the requirements of special rules in the production of judicial construction and technical expertise (in the order of discussion) // Недвижимость: экономика, управление. 2023. № 4. С. 73–78.

UDK 332.36

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Content analysis of the category of effective use of urban territory

At the present time, Russia is actively developing mechanisms for integrated territorial development, the main purpose of which is to increase the efficiency of the use of urban areas. The analysis of scientific literature has revealed many different formulations of this concept, however, the most rational way to reveal the meaning of the category of effective use of territories is to divide it into several components. The efficiency of using urban territory as a complex category includes its key components: social efficiency, economic efficiency, architectural and planning efficiency, infrastructural efficiency, sanitary and environmental efficiency and investment efficiency. Based on the analysis of scientific literature, it was determined that in the context of solving the problems of urban development and socio-economic development of the territory as a whole, it is advisable to consider investment efficiency as a basic element of urban development. At the same time, it should be noted that in a large number of cases, urban development projects are not commercial, in such cases investment efficiency is achieved either through mechanisms and means of state support, or by including elements in the content of the project that ensure investment efficiency. A number of principles that contribute to the efficiency of territorial development were also identified. On the basis of the study it was concluded that the problem of managing the development of urban areas to a significant extent can be reduced to ensuring an optimal balance between the individual aspects of urban planning efficiency, the basic one of which is investment efficiency, in the context of project implementation, taking into account strategic goal setting and ensuring the sustainability of urban planning environment.
Keywords: *urban planning, efficiency of territory use, urban planning efficiency, investment efficiency, principles of territory development, functional zoning*



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Recently, the number of vacant urban areas in Russia that could be used for housing and any other construction has been decreasing, while in Russia there is a significant percentage of emergency housing, therefore, on December 30, 2020, the Federal Law "On Amendments to the Urban Planning Code of the Russian Federation and Certain Legislative Acts of the Russian Federation in order to ensure a comprehensive development of territories" No. 494-FZ. As a result, a new mechanism has appeared in the urban planning code — the mechanism of integrated development of territories. The main objectives of its introduction are[1]: ensuring balanced and sustainable urban development, creating conditions for the development of transport, social and engineering infrastructure, urban landscaping, and the most interesting goal is to increase the efficiency of urban use. Despite the use of the concept of "efficiency of the use of urban areas", there is no definition of it in the urban planning or any other code.

Based on the results of the analysis of scientific and educational publications devoted to the problems of urban management, it can be concluded that there are a large number of alternative interpretations of the content of the category of effective use of territories [1–4]. In most cases, the authors apply the category of urban planning efficiency to indicators and characteristics reflecting the degree of efficiency of urban use. The concept of urban planning efficiency contains a number of areas that have both internal relationships and an internal hierarchy. Within the framework of this paper, the main areas related, according to various sources, to the category of urban planning efficiency and reflecting the degree of efficiency of the use of urban territory are presented. In the scientific literature, urban planning efficiency is divided into 6 main components (Fig.) [5–8]:

1. *Social efficiency* — evaluates the diverse effect of the chosen layout, including the possibility of employment by representatives of various professions, the variety of vacancies offered directly in the area helps to reduce the need to make unproductive trips to other parts of the city, which reduces the load on the urban transport network, increasing the comfort of life of residents of the area, as well as reducing their transport costs.

2. *Economic efficiency* — in a general sense is obtaining the maximum possible benefits from available resources [9], however, in this case, this indicator should be perceived as the effect of using the territory in the form of an increase in the number of workers, changes in the level of gross domestic product, changes in the production potential of the territory, and so on.

3. *Architectural and planning efficiency* — evaluates the effect of the selected structure of residential, industrial and recreational areas. With a well-chosen district structure, the interaction of various functional zones creates a synergistic effect that increases the comfort of local residents, which, for example, manifests itself in the convenient location of places of sale of goods of daily demand.

4. *Infrastructural efficiency* — the degree of satisfaction of the local population with the existing social, engineering and transport infrastructure.

1 Urban Planning Code of the Russian Federation : dated 12.29.2004 No. 190-FZ (as amended on 08.04.2023) (with amendments and additions, introduction. effective from 09.01.2023).

This indicator is especially important in the complex residential development of new territories, which are often located in areas of the city that do not have adequate provision even with engineering infrastructure, therefore, the construction of infrastructure facilities in such situations is a key task.

5. *Sanitary and environmental efficiency* — evaluates the rationality of the relative location of residential areas and industrial zones, it is worth placing the latter away from residential areas, it is also necessary to take into account the wind direction. With the correct arrangement of these mutually exclusive associations of similar objects, the harm to the health of residents of residential areas will be minimal due to the absence of air pollution with harmful substances.

6. *Investment efficiency* — Most researchers agree that the basic element of urban planning efficiency, which provides the opportunity to attract resources for the implementation of urban development projects, is investment efficiency, which includes certain aspects that ensure the effectiveness of investment, taking into account alternative financing mechanisms and alternative organizational models for the implementation of investment and construction activities.

In the context of solving the tasks of urban development and socio-economic development of the territory as a whole, it is advisable to consider investment efficiency as a basic element, however, it should be noted that in a large number of cases urban development projects are not of a commercial nature, in such cases investment efficiency is achieved either through mechanisms and means of state support, or other forms of support, or by including elements in the content of the project that ensure investment efficiency. In this case, the key aspect of urban planning is the search for an optimal balance between the individual components of the project in the context of solving the tasks of urban development, taking into account the investment attractiveness for individual participants of the investment and construction project.

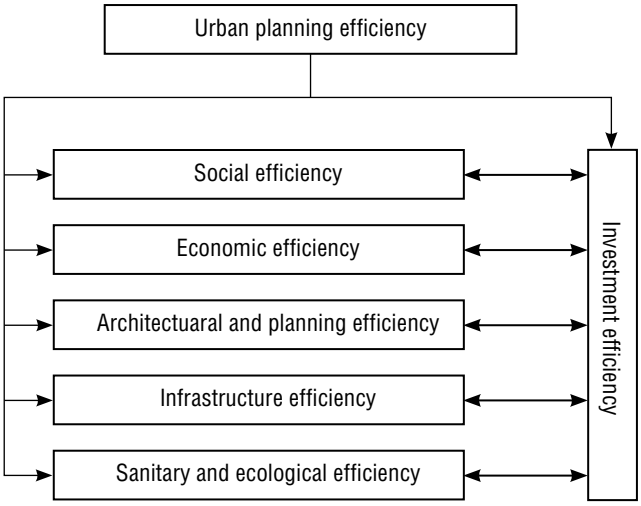
In order to achieve the goals of urban development of territories, namely, to ensure a favorable living environment and create conditions for the effective use of territorial resources [10] in scientific sources [11–14], the following basic principles of effective development of territories are proposed:

1. The principle of *suboptimization* — according to this principle, optimization of individual subsystems does not lead to optimization of the system as a whole. Thus, when planning a territory, it is necessary to take into account the interconnection of its individual elements, and not focus on isolated areas-subsystems. For example, the efficient location of an oil refinery can significantly reduce the efficiency of the location of the entire city.

2. The principle of *long–term planning* — the layout of the territory should be developed taking into account the duration of its existence. The consequences of planning decisions will have consequences in 50–100 years or more.

3. The principle of *consistency and continuity* — when designing, it is necessary to take into account the relationship with neighboring territories, the possibility of combining into a single system, that is, it is necessary to take into account the advantages associated with the potential growth of the system.

4. *Complexity* — integrity and balance of the urban environment, the quality of life of the residents of the district depends on compliance with this principle, an excess of some and a shortage of other infrastructure facilities or functional zones may cause dissatisfaction of the local population or, at least, inefficient use of the territory, for example, with an excess of shopping centers, some of the rented premises will not be available after some time have a tenant.



Structure of elements of urban planning efficiency

5. *Functionality* — ensuring the maximum balance of diverse functional connections of the population within the territory by reducing unproductive citywide trips.

6. *Compactness* — ability of the project to concentrate on a limited area all the objects necessary for the functioning and development of the city. Multifunctional complexes can serve as an example of solving the problem of compactness, increasing the height of a building can also solve the problem of increasing the compactness of buildings, however, the need to place all the necessary facilities in the area one way or another leads to a decrease in the area of residential buildings.

7. *Environmental friendliness* — principle implies reducing the negative impact of capital construction projects at the operational stage, which has a positive effect on the environmental situation of the entire city, which somehow increases the standard of living of all residents of the city.

8. The principle of *zoning the territory* — principle implies that when designing it is necessary to plan several functional zones and provide for their further growth. Compliance with this principle will avoid the appearance of undesirable chaotic intersection of industrial, residential, transport and recreational zones, as a result of which it will be possible to prevent serious economic losses, air pollution, as well as the rise in the cost of transport and engineering communications.

Based on the results of the analysis, it can be concluded that the category of effective use of urban territory is complex, including certain aspects characterized by mutual influence and variability over time. In this case, the problem of managing the development of urban areas to a significant extent can be reduced to ensuring an optimal balance between certain aspects of urban planning efficiency, the basic of which is investment efficiency in the context of project implementation, taking into account strategic goal setting and ensuring sustainable development of the urban area.

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Анализ содержания категории эффективного использования городской территории

В настоящее время в России активно развиваются механизмы комплексного территориального развития, основной целью которого является повышение эффективности использования городских территорий. В результате анализа научной литературы было выявлено множество различных формулировок данного понятия, однако наиболее рациональным способом раскрытия значения категории эффективного использования территорий является разделение его на несколько составляющих. В результате рассмотрения эффективности использования городской территории как комплексной категории были выявлены ее ключевые составляющие: социальная, экономическая, архитектурно-планировочная, инфраструктурная, санитарно-экологическая и инвестиционная. На основе анализа научной литературы было определено, что в контексте решения задач градостроительного развития и социально-экономического развития территории в целом целесообразно рассматривать инвестиционную эффективность как базовый элемент градостроительного развития. Вместе с тем следует отметить, что в большом количестве случаев проекты градостроительного развития не носят коммерческого характера, в таких случаях инвестиционная эффективность достигается либо за счет механизмов и средств государственной поддержки, либо путем включения в содержание проекта элементов, обеспечивающих инвестиционную эффективность. Также был выявлен ряд принципов, способствующих повышению эффективности развития территорий. На основе проведенного исследования был сделан вывод о том, что проблематика управления развитием городских территорий в существенной степени может сводиться к обеспечению оптимального баланса между отдельными аспектами градостроительной эффективности, базовым из которых является инвестиционная эффективность, в контексте реализации проектов с учетом стратегического целеполагания и обеспечения устойчивости градостроительной среды.

Ключевые слова: *градостроительство, эффективность использования территории, градостроительная эффективность, инвестиционная эффективность, принципы развития территории, функциональное зонирование*

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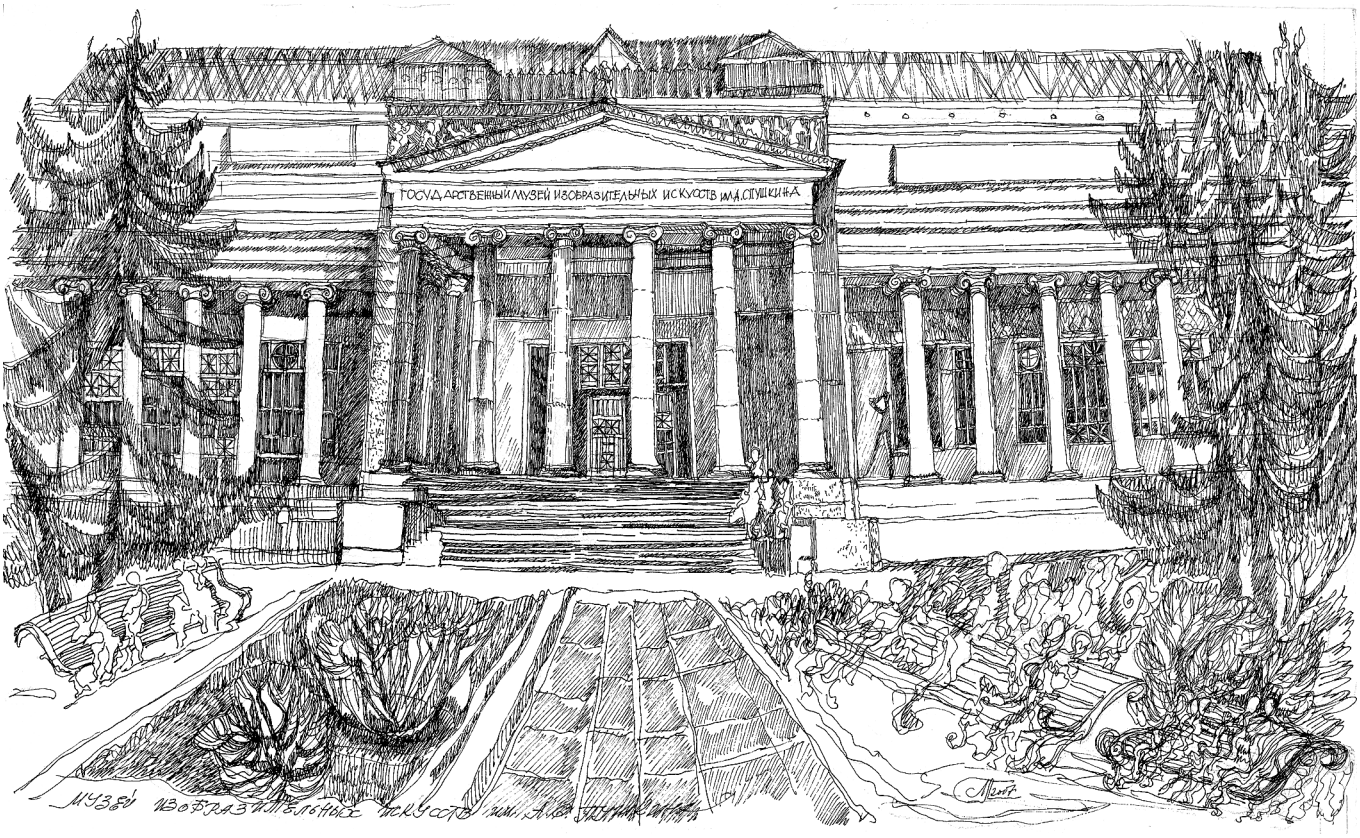
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For citation: Solovyov A.A. Content analysis of the category of effective use of urban territory. *Real Estate: Economics, Management*. 2023; 4:79-82.

Для цитирования: *Соловьёв А.А.* Content analysis of the category of effective use of urban territory // Недвижимость: экономика, управление. 2023. № 4. С. 79–82.



Москва. Музей изобразительных искусств им. А.С. Пушкина. Рисунок, тушь, перо