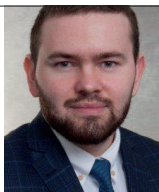


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Experience in the classification of innovative construction technologies in digital format

This article deals with the problem of the digital revolution, which in recent decades has led to the rapid pace of innovation not only in the global industrial sector, but also in science, medicine, education and other areas of human activity, providing them with a significant increase in productivity, profitability, labor productivity, and safety for the environment. However, this has hardly affected the construction industry, which has not undergone significant changes over the past 50 years. This article reveals the content of the main reason for the extremely slow pace of innovative processes in construction, due to its global scale and decentralized nature. The construction industry accounts for approximately 6 % of global GDP (and for developing countries it reaches 8 % of GDP) and continues to grow. Special attention is paid to the fact that construction is the largest consumer of resources, which annually uses about 50 % of the total volume of steel produced and more than 3 billion tons of raw materials. Therefore, any innovation that leads, for example, to increased productivity in construction, on a global scale could save \$100 billion a year. Also, this paper shows the factors that make construction a difficult business, which is not amenable to the necessary transformations. The article presents the basic principles of building an automated information support system.

Keywords: digital revolution, increasing productivity, innovative processes

Construction is a leading infrastructure industry, creating and integrating 21 % of the world's GDP and 6 % of the GDP of the Russian Federation. About 2.9 % of the world's population is involved in this sector, most of the natural resources used in this market are consumed, 31...40 % of waste is created, and 25 % of carbon dioxide emissions are generated. In contrast to many sectors, construction under the influence of the COVID-19 pandemic decreased insignificantly (–1.2 %), and its recovery is planned for next year: the average annual rate of increase in market share from 2021 to 2023 is projected to be 6.9 %. The drivers of the construction sector are the increase in the world population, the processes of concentration and the economic boom in developing countries.

Despite the serious potential, construction traditionally invests little in information and digital innovations and systems, and slowly implements them.

Construction companies invest only 2.1 % of their revenue in IT (4.1 % on average in other sectors)¹.

According to analysts, digitalization and automation can significantly improve labor productivity (9...13 %) and business profitability (7...8 %), improve the safety of construction work, qualitatively develop the operational performance of buildings and reduce investment in infrastructure. The environmental identifiers of the construction market also largely depend on the use of technology and innovation.

Defeating conservatism, the construction industry is becoming more digital and automated, and technology is penetrating the processes from design to operation of buildings and infrastructure.

In the part "Digitalization of the construction industry" of the Strategy for the Development of the Construction Industry until 2030, the main mechanisms for the implementation of urban planning operations in

digital format are highlighted, as well as the schedule for the transfer of urban planning procedures to electronic form in the Russian Federation²:

- since July 2011, the GrC has developed a regulation on the potential for sending documents for obtaining a construction permit and a permit for putting objects into operation in electronic form;
- in July 2016 The Government of the Russian Federation and the main executive bodies of state power of the subject of the Russian Federation (in relation to the executive authorities of the subjects of the Russian Federation, local self-government bodies) have been granted the right to identify cases of sending documents necessary for obtaining a construction permit, a permit for putting an object into operation only in electronic form.

Referring to the decree of the Government of the Russian Federation of 09.08.2017 No. 955³ in three subjects of the Russian Federation (Moscow, Moscow region, St. Petersburg), an experiment is being carried out to translate into electronic form the operations of providing technical conditions by organizations that operate engineering and technical support networks.

At the moment, many leading development companies in the Russian Federation are implementing their innovative solutions based on the digital

² Section "Digitalization of the construction industry" of the Strategy for the development of the construction industry until 2030. URL: <https://www.nopriz.ru/upload/iblock/892/TSifrovizatsiya-stroitelnoy-otrasli-dlya-Strategii.pdf>

³ Resolution of the Government of the Russian Federation of 09.08.2017 No. 955 "On Establishing the Specifics of Providing Services for Connecting" (Technological Connection) Capital Construction Objects to Engineering and Technical Support Networks in Electronic Form on the Territory of the Moscow Region and the cities of Moscow and St. Petersburg. URL: <http://publication.pravo.gov.ru/Document/View/0001201708150019>

¹ Strategy for the development of the construction industry of the Russian Federation until 2030. URL: <http://stroystrategy.ru/#about>

transformation of each company's strategies, which affect both the operational efficiency of each company and the sector and economy of the Russian Federation, due to the fact that construction is a fundamental driver of the economy of the country and the world as a whole.

The table below provides a brief analytical overview of the use of digital innovation products and their integration into the existing operational activities of development companies in Moscow. This analysis covers the name, main tasks and functionality that these digital products carry, as well as their effect on the operating activities of companies. All information collected from digital products was based on information from the last 5 years from 2016 to 2021 and is informative in nature.

The Buildup startup accelerator is a qualitative iteration of the selection and formation of a pool of digital innovative solutions for the organizational and economic mechanism for implementing construction innovations in the digital environment of the customer/developer (as a control element). It performs the function of an integrator of one of the seeding stages.

After the formation of this stage, a corporate fund is integrated and created with the method of selection and multiplicative evaluation of the effectiveness for the company. At the moment, the formation of this structure in the main business of development companies is practically not happening, but there is a clear prospect of developing prototype types of business from other areas, such as banking, information technology, large infrastructure projects.

For 2021, 4 large construction corporations have already been designated in Skolkovo to implement the results and 3 pilot projects.

Of course, I would like to note the assistance of the city authorities in this matter. So, in February 2021, at least 40 technological solutions will be tested in Moscow under the innovation testing programme. The government of the capital is forming a programme of pilot testing of innovative solutions from 2019. Thanks to it, startups and already established high-tech companies in construction have

a chance to test their products on certain commercial or urban projects. This helps entrepreneurs evaluate the prospects and competitiveness of their developments, as well as optimize them before they are put on the market, thanks to feedback from consumers.

Since the launch of the programme, more than 50 technological projects have been successfully tested. About 30 more are still in the process. Developers now have access to 108 sites for testing modern digital solutions^{4, 5}[1]. They represent such areas as information technology, BIM design, construction, sales and marketing in development, industry and manufacturing. This year, it is planned to conduct at least 40 tests, and the pool of the best will be implemented, including on state-commissioned projects⁶ [2].

I would especially like to note the close cooperation of representatives of the construction sector in the Russian Federation with the international community (table). The largest general contracting structures, such as Ant Tech, FODD, Ant Yap, Svargo, Renaissance Construction and others are already actively exchanging experience in the application of innovative digital technologies at their facilities with their colleagues from the United States, Europe, and China, as well as organizing numerous conferences, workshops, scientific symposiums and many other events that undoubtedly have a fruitful impact on the system and culture of work at the sites and projects of the capital.

Based on the analysis, it can be concluded that various types of digital innovative solutions already help to optimize many

4 Passport of the national project "Housing and Urban Environment", approved by the Presidium of the Council under the President of the Russian Federation for Strategic Development and National Projects on December 24, 2018 (Protocol No. 16). URL: <http://static.government.ru/media/files/i3AT3wjDNyEgFywnDrcrnK7Az55RyRuk.pdf>.

5 The action plan "Transformation of the business climate", approved by the Order of the Government of the Russian Federation of January 17, 2019 No. 20-r (direction "Urban development and territorial planning"). URL: <http://static.government.ru/media/files/RDLjpvAMGczA7PIJ8PXN2MljC9VvJNA.pdf>.

6 GOST R 57363–2016. Project management in construction. The activity of the project manager (technical customer).

The main digital solutions and products used in the main development companies in Russia

Company	Innovation	Type of innovation	Description	The effect of innovation	Origin
PIK VTB GROUP OF COMPANIES  	CRM system with two "funnels"	Organizational	Common system for monitoring land asset management tools	Optimization of internal business procedures for the consolidation of the company's integrated systems and reduction of costs by 10 %	Microsoft Dynamics CRM
	"Digital General Contractor"	Technological	A single platform for managing the contractual relationship between the customer and the general contractor	Innovative control of contractors, reducing the approved budget for the CMP by about 15 %	Express 42
	VMware Horizon ®	Product	Creating Virtual Workplace programmes (VDI) using 3D graphics cards	Transfer of 35 % of the number of full-time staff to remote work, reduction of expenses by 22 % on the operating activities of the development company	Selectel
	Virtual Foreman	Organizational	A tool for construction contractors with a "virtual foreman" and the ability to attract individual specialists on request-online marketing platform	Optimization of the costs of social payments and taxes (primarily by attracting the self-employed), avoiding downtime in work and, as a result, reducing the cost of general contract contracts	Internal IT product of PIK-Industry

	Digital product for online mortgage transactions	Product	Purchase of a mortgage loan using a digital platform	Updated tool in the system of mortgage transactions, which helps Developers to optimize about 15 % of the cost of registration of mortgage sales	Secure payment service "Square Meter"
	"Smart" system for analyzing physical labor	Technological	Artificial intelligence technologies for recognizing and analyzing manual labor	Allows you to increase productivity by 20 % at once. These solutions allow you to develop the right algorithms and form, as a result, a two-level control system.	Structure of the LANIT Group of companies, SUTO startup
KROST Concern 	The Maginot Factory	Technological	Enterprise for the production of precast concrete, architectural concrete with implemented innovative solutions based on modern technologies and integrated information solutions	Control of the operational activities of the designers, as a result, optimization of the price of the design contract by 20 %	SaaS IT system
	Factory "FIBROL"	Technological / Marketing	Own high-tech production of any products made of fiber-reinforced concrete and glass-fiber-reinforced concrete	"FIBROL" produces an extensive range of elements. The factory's technologies allow you to get a lot of invoices and various shapes using 3D printers, an increase in orders according to the sector when working with external customers by 18 %	Integration of BI products in integration with your own design office and contractors
	Climate chamber	Product	Climate chamber, which will make it possible to test integrated types of facade structures for resistance to the influence of natural factors.	Control of design solutions for facades, optimization of the budget by 10 % according to the approved estimated prices for the section "Facades"	NIISF RAASN/ Krost Concern
ГК Эталон 	Profitbase Platform	Organizational	Dynamic pricing cloud software	The product identifies the most profitable cost of an apartment and a square meter in real time in order to achieve maximum project profit	Profitbase platform
	Digital system for payment for booking services of objects	Marketing	A joint project with Sberbank, providing access to remote opening of escrow accounts and signing contracts without visiting bank offices.	For 2019–2020, it allowed to increase apartment sales by 7 % in absolute terms.	Own IT development based on systematized solutions of Power BI, AI, ML
	Remote registration of a mortgage agreement	Organizational / Product	An online real estate store integrated into a single platform, where you can conduct transactions through the service of a common operator in his personal account	Increase in sales by 6 % year-on-year, as well as improve the quality of internal business processes	The internal software of the company Etalon is based on the implemented CRM system.
	Digital Aggregator "Integrated construction and Design Control System"	Organizational	Development of a company that reflects all stages of the life cycle, as well as automatically detects inconsistencies from approved budgets, schedules and contractual obligations	Optimization of personnel FOT costs by 3 % in absolute terms, optimization of design solutions by 7 % based on each section of the RD, bias in the KR, optimization of the project budget by 4 % with the help of expenditure control	CRM systems, machine learning — internal development of the company

 Don-stroy Invest	Data Fuel Software	Marketing	The Data Fuel programme- personalization of clients based on Big Data, as well as building links between the client's past purchases on the Internet in the real estate sector and, as a result, building a road map of the client's desires and interests	Improve scoring and communication models with sustainable customer data. Providing 10 psychographic parameters and building a map of preferences by property type and price	BIG DATA product from DataFuel
	Software "All keys in one smartphone"	Product	A combined system product that helps to eliminate inconveniences for customers in terms of managing the infrastructure systems of a residential complex, including a parking system, automatic door opening, control of engineering devices, and much more	By the end of 2020, about 10,000 customers of the company had already used this product, and the income from additional services covered the costs of developing software for the company in absolute terms.	UHF-RFID long-range reading technology
	Archicad, BIMx, and BIMcloud by GRAPHISOFT	Organizational	Interaction and integration with other BIM programmes and platforms in a single common software cloud for managing the design process, cost planning and labor costs on the construction site	Cost optimization for the implementation and operation of GRAPHISOFT's BIM solutions and, as a result, BIM technologies become cheaper for the Customer	Archicad, BIMx, and BIMcloud by GRAPHISOFT
	Profitbase Ai Platform	Organizational	The platform includes information solutions for developers, such as CRM, the buyer's personal account, BI dashboards-interfaces with accessible information display for updated and better business processes	This decision made it possible to reduce the project budget approved by the project committee by 5...7 %	Service product from the company Profitbase Ai
	Trace Air Product	Technological	A cloud service that calculates the amount of work performed, for example, earthwork, using drones and compares it with the data of estimates and acts of work performed	The accuracy of control over the specified type parameters of contractors' work increased by 10...15 %, which allowed to reduce about 10 % of the initially estimated amount and, as a result, improved internal control over contractors, in terms of protecting the acts of work performed	TraceAir software company
 PJSC "Gals Development"	Control automation systems in apartments and apartments of the company's residential complexes	Marketing	Smart Apartments is a platform that integrates the management of engineering systems of apartments in a mobile application on a smartphone. The system operates on the basis of a central controller with the use of wired and wireless solutions	The most important and tangible advantage of the technology is the scenarios defined for each client, which allow residents to control the control of lights, sockets, heating, air conditioning, curtains, etc. The system also registers leaks and blocks water supply risers if they are detected, and automatically contacts the operating organization if there are more serious cases of power outages in the house.	PJSC "Gals Development"/ LLC "LIIS Engineering Solutions"
	G-tech modular hinged ventilated facades	Technological / Marketing	Modular hinged ventilated facades that include architectural features and increase the speed of installation.	When using this system, the construction of facades is carried out in parallel with the construction of a monolithic frame, which allows you to speed up the completion of facade work by 30 % (1.5–2 months after the end of monolithic work)	Genesis Company

PJSC "Gals Development" 	"Prestige Service Technology"	Technological	Technology of non-destructive instrumental control of detection of leaks of a soft roof	An integrated leak detection method that allows you to find leaks immediately after they occur. At the same time, the accuracy of localization of defects is 1 mm. Other obvious advantages of the method are its versatility and high speed of examination.	Joint product of PJSC "Gals Development"/ "Prestige Service"
	Fogstream Fire Extinguishing System	Technological	Fogstream Fine Water fire Extinguishing System	Fire extinguishing system with thinly sprayed water with 5–10 times water usage savings, minimal damage, saving technical space, fast installation, reducing capex and opex by 10...15 %	Joint product of PJSC "Gals Development"/ Fogstream
	Specialized spark protection device (ultrasound with)	Technological	Specialized spark protection device (ULTRASOUND c) of the Russian company "Ecolite" for automated fire prevention	The specialized spark protection device (USIs), developed and manufactured by the Russian company "Ecolite", is designed for automated fire prevention from sparking in electrical networks and electrical installations connected through it to the power supply network. The device detects a spark in the protected circuit and disconnects it.	Joint product of PJSC "Gals Development"/ "Ecolite"
	Complex for charging electric vehicles Simple	Technological / Marketing	A complex for charging electric vehicles Simple Charge with the functions of finding all existing charging stations in the user application, cashless payment, management and charging of electricity for the owners of the charging station	Software and hardware complex for charging electric vehicles, which includes the functions of searching for all charging stations in the user application, booking them, non-cash payment for motorists, and managing and charging electricity for the owners of the charging station. The solution consists of a charging station, a control controller, and software. This software is a convenient service for owners of electric vehicles and charging stations in the face of growing demand for electric vehicles in the world	Joint product of PJSC "Gals Development"/ Simple Charge
	VIM System	Marketing	System-widget for visualizing apartments on the website of a residential complex	Familiarization with the project declaration and construction permit without necessarily downloading the file to your computer. Interactive 2D plan of the building and apartments. Interactive layout with the necessary information for the visitor, as well as the layout of neighboring apartments with the ability to go to their cards or other floors of the active section. Interactive 3D visualization of buildings, buildings and apartment layouts	Joint product of PJSC "Gals Development"/ VIM

business processes in development projects and, thereby, reduce the cost of projects. Further steps to integrate these products into the operational business of both customers and general contracting structures will inevitably lead to an increase in the quality of sales of various products in their price segments.

Speaking about the innovative future of construction, today we distinguish 3D and modular construction, advanced building materials, additive manufacturing, autonomous machinery and equipment, including drones, augmented and virtual reality, big data and predictive analytics, wireless monitoring, sensors, connected equipment, cloud and communication solutions, 3D scanning and photogrammetry, information modeling.

Technology services and tools for construction have been evolving since the early 2000s, forming a growing ecosystem. And in recent years, there has been a quantitative and qualitative growth. So, only in 2016–2020, the number of startups, as well as already established companies that are repurposed for the creation of digital innovative products, increased by 4.5 times [3, 4]. At the moment, the number of patented companies whose products or software are somehow used in the implementation of development, construction, and production projects is about 4,300 companies, which gives full confidence that this area will actively develop in the coming years, thereby giving an impetus not only to the construction industry, but also to the country's economy in particular.

Taking into account the order of the Cabinet of Ministers and the Central Bank of February 15, 2021, the President of the Russian Federation to issue proposals for preferential mortgages until 2024, having considered a reduction in the rate for families with two or more children, there are real aspects of understanding that development structures and the entire market in particular will feel competitive and the marginality of projects will be at an increased level, which will allow attracting new innovative and digital solutions to their operational activities.

In addition, taking into account the fact that without an affordable mortgage, it will be impossible to fulfill the ambitious programme for the construction of 1 billion square meters of housing that the government is facing, the application of these solutions becomes even more relevant. After all, the mortgage boom is a factor that will spur developers to increase the volume of new housing and, as a result, increase profits, which will certainly be an incentive to attract companies that develop certain innovative and digital products.

We should also mention the fact that 78 % of customers in the Moscow region already use the BIM system in their projects. It is important that the transition of the entire industry to BIM will help significantly reduce the number of inconsistencies and shape the dynamics in the role of design and construction of facilities in Russia. Starting from January 1, 2022, all state customers in construction will be required to implement projects using BIM. In general, the industry should make this "digital" transition in a maximum of 1–2 years: for this purpose, all regulatory documents have already been adopted, and a classifier of information has been developed.

As the analysis of innovations of the largest development companies has shown, innovative technologies today should be understood not only as new construction technologies, materials and design solutions, but also as all components of construction and development activities: improvement of business processes, sales system, construction control and cost control systems, and resource savings.

The main goal and directions of innovative development of developers, including through the involvement of startups—this is everything that allows you to optimize the time and cost of construction; to make a technological breakthrough in key aspects of quality for consumers: comfort, energy efficiency, environmental friendliness and Internet support.

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Опыт классификации инновационных строительных технологий в цифровом формате

В статье рассматривается проблема цифровой революции, которая за последние несколько десятилетий привела к росту темпа инноваций не только в общемировой промышленности, но и в науке, медицине, образовании и других областях деятельности человека, обеспечив существенный рост продуктивности, прибыльности, производительности труда и безопасности для окружающей среды. Однако все это мало отразилось на строительной отрасли, которая не подвергалась значительным изменениям на протяжении последних 50 лет. В статье раскрывается суть исключительно медленных инновационных процессов в строительстве, которая заключается в их глобальном масштабе и децентрализованности. На долю строительной отрасли приходится примерно 6 % общемирового ВВП (в развитых странах этот показатель составляет 8 % ВВП), и эта цифра продолжает расти. Особое внимание уделяется тому факту, что строительство является крупнейшим потребителем ресурсов: данная отрасль ежегодно использует около 50 % суммарного объема потребления производимой стали и свыше 3 млрд т сырьевых

материалов. Таким образом, инновации, которые ведут, например, к росту производительности строительства, могли бы в общемировом масштабе сэкономить 100 млрд долл. США в год. Кроме того, в статье указаны факторы, наличие которых превращает строительство в сложный вид коммерческой деятельности, трудно поддающийся необходимым преобразованиям. В статье представлены основополагающие принципы построения автоматизированной системы информационной поддержки.

Ключевые слова: цифровая революция, рост производительности, инновационные процессы

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