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Managing the information potential of a construction company in the transition to a digital economy

Gestionar el potencial de información de una empresa de construcción en la transición a una economía digital

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Contents

ABSTRACT:
The relevance of the study is determined by the need to improve the effectiveness of the strategy for the information society development, ensuring the achievement of the strategic goals of sustainable development of construction organizations in the context of information inequality and the digital divide of regions. The purpose of the study is to develop conceptual provisions and methods that expand the toolkit of the mechanism for the digital economy development in the construction industry. A mechanism for managing the information potential of a construction enterprise is proposed. A common information space model was worked out for a construction enterprise and a procedure for selecting components of an integrated information system of construction organizations was developed.
Keywords: digital economy, information policy, information potential, digitalization, common information space, factor analysis

RESUMEN:
La relevancia del estudio está determinada por la necesidad de mejorar la efectividad de la estrategia para el desarrollo de la sociedad de la información, asegurando el logro de los objetivos estratégicos del desarrollo sostenible de las organizaciones de la construcción en el contexto de la desigualdad de la información y la brecha digital de las regiones. El propósito del estudio es desarrollar disposiciones conceptuales y métodos que amplíen el kit de herramientas del mecanismo para el desarrollo de la economía digital en la industria de la construcción. Se propone un mecanismo para gestionar el potencial de información de una empresa de construcción. Se elaboró un modelo de espacio de información común para una empresa de construcción y se desarrolló un procedimiento para seleccionar componentes de un sistema de información integrado de organizaciones de construcción.
Palabras clave: economía digital, política de información, potencial de información, digitalización, espacio de información común, análisis factorial

1. Introduction

In the current conditions of globalization, the construction industry is highly dependent on the

information part of the resource potential. Construction in itself is sufficiently informative, and the constant updating of technologies, regulatory framework and external conditions of activity creates dependence on the information environment.

The purpose of the research is to work out a conceptual framework for the implementation mechanism of the Digital Economy of the Russian Federation program in the construction sector and to develop practical measures improving the efficiency of information potential management in construction.

In accordance with the research purpose, the following tasks were formulated: to justify the need for the development of information and communication infrastructure in construction; to reveal the mechanism for the formation and implementation of a common information space, to propose a unified methodological approach to automation in the construction sector and to suggest the lines for improving information potential management efficiency in a construction enterprise.

The object of the study is Digital Economy of the Russian Federation program and its application in the construction industry within the framework of the Digital Construction project.

The subject of study is a set of methods, forms and tools that contribute to the effective management of the information potential in a construction company and to the implementation of the mechanism for construction industry digitization.

Digitization and the need to manage information potential in construction is conditioned by the increasing role of information in the construction sector, the increasing share of information and communication technologies, information products and services in the gross domestic product of the construction industry and the creation of a global information infrastructure that ensures information interaction of personnel potential, their access to information and meeting their social and personal needs (RF Government Resolution No. 1030, 2017; RF Government Ordinance No. 1632-r. 2017).

Information acquisition and interpretation are integral parts of any enterprise’s development strategy implementation. Information support of the construction business brings a number of new conditions in terms of technology:

- formation of new communication channels for data exchange within the system with the pronounced speed of interaction and computational capabilities;

- territorial and local approximation of information tools to the construction sites, creating the possibilities of remote monitoring and directing control pulses with a high speed of information delivery;

- integration of enterprises in the sectoral, national and global economic space, creation of enterprises’ integrated interaction systems;

- creation of centralized control systems and standardization of construction processes;

- increase in the level of information richness of production operations, transition from accounting and computing tasks of information systems (IS) to management processes.

Russian construction industry is characterized by the presence of small enterprises engaged in occasional activities. In the environment of these enterprises, the use of information system and information technology has no development practically, and the application does not go beyond solving accounting problems using standard developments for enterprise management. Even the distributed computing technology does not find application, despite its obvious convenience and the possibility of saving money on the rental of expensive server hardware and administration outsourcing. The issues of integration into the information space are approximately at the same level for small and large companies: this is an IS architecture formation and engineering based on the existing developments and hardware-software communication tools (Dzhuliy and Yemchuk, 2015; Kudinov, 2011a).

Informatization of construction enterprise management is a task of the level of complexity which necessitates using solutions adapted to the specifics of production activities, since the tasks of construction production have their own degree of uniqueness that is explained by the variety of objects, products and related technologies (Kudinov, 2011b).

The novelty of the research results consists in the development of an information potential

management mechanism that provides a scientifically based choice of components of an integrated information system and formation of a common information space in a construction enterprise.

The hypothesis of the research is based on the assumption that in the context of implementing the "Digital Construction" Federal Project it is necessary to create an industry-wide digital platform that provides automation of all stages and procedures of a construction enterprise's lifecycle, as well as the development of a scientific and methodological approach and practical recommendations to manage the information potential of a construction enterprise, which will significantly reduce construction costs and strengthen its competitive positions in the market.

1.1. Literature review

The investment policy formation and implementation mechanism is laid in the regulatory framework of the Russian Federation. Presidential Decree No. 203 (2017) stipulates goals, tasks and measures for implementing the domestic and foreign policy of the Russian Federation in the field of information and communication technologies aimed at the information society development, formation of a national digital economy, provision of national interests and implementation of strategic national priorities. The strategy involves the creation of an ecosystem of the digital economy in the Russian Federation, which will contribute to improving the quality of life and creating favorable conditions for doing business (Presidential Decree No. 642, 2016; RF Government Ordinance No. 1632-r, 2017).

The complex of measures envisaged by the "Digital Construction" Federal Project should ensure the digital transformation of the construction industry by 2024. A single digital platform should appear by this date, uniting all IT systems in the construction industry (Tabunschikov, 2018; Andreeva et al., 2018). Digitization of the construction industry involves the automation of all stages and procedures throughout the entire lifecycle of an object. According to the forecast of the Ministry of Construction, the transition to digital construction will enable to reduce temporary and other costs for facilities erected at the expense of the budgets of the Russian Federation at all levels to 20% over 5 years. At the same time, the reduction of the time from taking a decision to build an object to its commissioning will reach 30% (Iksmedia, 2018).

The problems of developing technology for building information modeling (BIM) and determining its place in the investment and construction process are at the center of attention of the scientific and professional communities of Russia and leading foreign countries, as well as international professional organizations.

The study of Hassinen (2017) is devoted to the issues of applying BIM technology in various implementation models of the investment-construction process. According to the author, a high probability of reducing the effectiveness or even complete loss of coordination of the project participants' activities is one of the main risks associated with the rapid introduction of BIM-technology in the investment and construction process. As a tool to reduce this risk based on the analysis of the experience of the Finnish construction company YIT, it is proposed to include a designated manager who will perform functions of the BIM coordinator into the team managing investment and construction projects.

Richard McPartland examines the transformation of the building information model during the lifecycle of a construction object in a series of publications. According to the author, a building information model as such exists only at the design stage of the object (McPartland, 2017). With the beginning of construction, it is transformed into a project information model (PIM), where temporary schedules, the arrangement of supply logistics to the construction site and the observance of budgetary constraints come to the fore rather than constructive characteristics of the object.

In addition, the project information model data should be ready for use as a basis for defending the positions of the parties in pre-arbitration disputes and arbitration proceedings.

Assessing the current stage of digitization in the construction industry of the Russian Federation, domestic researchers note that at present the use of BIM technology is limited mainly by pre-design studies and design of construction objects, that is, it does not go beyond computer-aided design systems, CAD (Dmitrieva, 2010). Thus, A.V. Ginsburg (2016) points to

the fact that in the Russian Federation the construction object lifecycle management system is a fragmented delinked set of subsystems, and building information modeling is not yet capable of combining these subsystems. He concludes that both the BIM technology itself and the mechanisms used to implement the investment and construction process must overcome a certain path of development and mutual adaptation to ensure a significant improvement in the coordination of goals, interests and actions of the participants in the object design, construction and operation processes.

Information modeling technology can be the basis for creating energy saving and building waste management systems throughout the entire lifecycle of buildings and structures, as well as for building integrated systems for construction and industrial waste management control covering entire cities and regions of the Russian Federation (Tskhovrebov and Velichko, 2015; Tskhovrebov et al., 2017).

Also, introduction of BIM at all stages of the investment and construction process opens the way to the wide use of the business model, which envisages receiving income from the provision of maintenance services, which are formed by providing the construction contractor and operator with paid access to information databases, selling various software applications and subscribing investment and construction process participants to digital services (Aziz et al., 2016; Edina, 2017).

A considerable number of foreign and Russian publications are devoted to assessing the economic and other positive effects of the introduction of information modeling at all stages of the investment and construction process (Malakhov, 2013; Trofimova and Trofimov, 2016).

According to the British Construction Products Association (CPA, 2016), the formation of national and regional information platforms based on BIM construction projects will reduce investment costs by more than 30%.

The analysis of the literature enables to conclude about the institutional and technological readiness of the construction industry of developed countries to integrate into the digital economy through the use of new digital platforms based on BIM technologies. There are successful ventures and prospects in this area in the Russian Federation, primarily in the most knowledge-intensive areas. Thus, the head of the Ministry of Communications and Mass Media of the Russian Federation N. Nikiforov, describing the process of introducing information modeling technology into communication infrastructure development projects, spoke about the prospects for integrating BIM technology with distributed registry technology, including in the context of using smart contracts in the near future (Alekseenko, 2017).

With regard to the significant contribution of these authors to the formation of the theoretical framework for digitization of the construction industry, it should be noted that the study of various aspects of using information technologies in the construction sector remains insufficiently developed. The insufficient level of consideration, relevance and increasing practical significance of this problem determined the choice of the topic and purpose of the study.

2. Methodology

The research is based on the theory of project management, methods of logical analysis, expert and rating assessments, grouping, comparison; typology, structural description, as well as systemic and optimization methods are applied that extend the scope of the application of the subject-functional approach to the formation of a set of measures to ensure the selection of the most prioritized areas of informatization and information resource management in construction companies.

Scientific and methodological developments of leading domestic and foreign experts and specialists of research centers, current analytical materials of relevant ministries and departments of Russia were used in the course of the study; the experience of major Russian construction companies and statistical reports from the Federal State Statistics Service on the subject under consideration were analyzed. The multidimensionality of approaches to solving the problem of developing and implementing information management in the construction industry necessitated the use of methods of the project management theory, systemic and optimization methods, functional completeness and expert assessments to formulate a set of measures to improve the management efficiency of a construction enterprise.

To solve specific problems, the methods of statistical and comparative analysis were used, as well as expert evaluations of professionals in the field of construction and information technology.

Russian Federal State Statistics Service (Rosstat) provides data on the penetration of information technologies into construction companies (FSSS, 2017): the use of a software product and a relatively advanced hardware base at the level of resource base management reaches 60.8%, with an increment of 1.5% per year. Despite the apparent growth, these figures cannot be called sufficient, since the equipment necessary for such use–a desktop PC–is available even at the household level, and the widespread outsourcing services and virtual server make it possible to refuse to purchase own more expensive devices (Table 1).

Table 1
Information on the use of information and communication technologies in the construction industry organizations

Information and communication technologies applied	2010	2014	2015	2016
Organizations that use broadband Internet access	69.1	85.3	84.3	85.0
Organizations that have a website on the Internet	24.0	34.2	38.6	41.8
Organizations that use electronic data exchange between their own and external information systems by economic activity	29.7	57.5	63.5	64.5
Organizations that use the Internet to communicate with suppliers and consumers of goods (works, services)	35.0	34.7	34.4	31.6
to place orders for goods	28.7	27.2	25.7	23.5
to receive orders for manufactured goods (works, services)				

Source: Compiled by the authors based on Abdrakhmanova et al., 2018; Rosstat, 2017; FSSS, 2017.

The effectiveness of changes that occur as IT penetrates the construction industry can be estimated by the growth of economic efficiency; the research allowed establishing a number of relevant indicators (Abdrakhmanova et al., 2018):

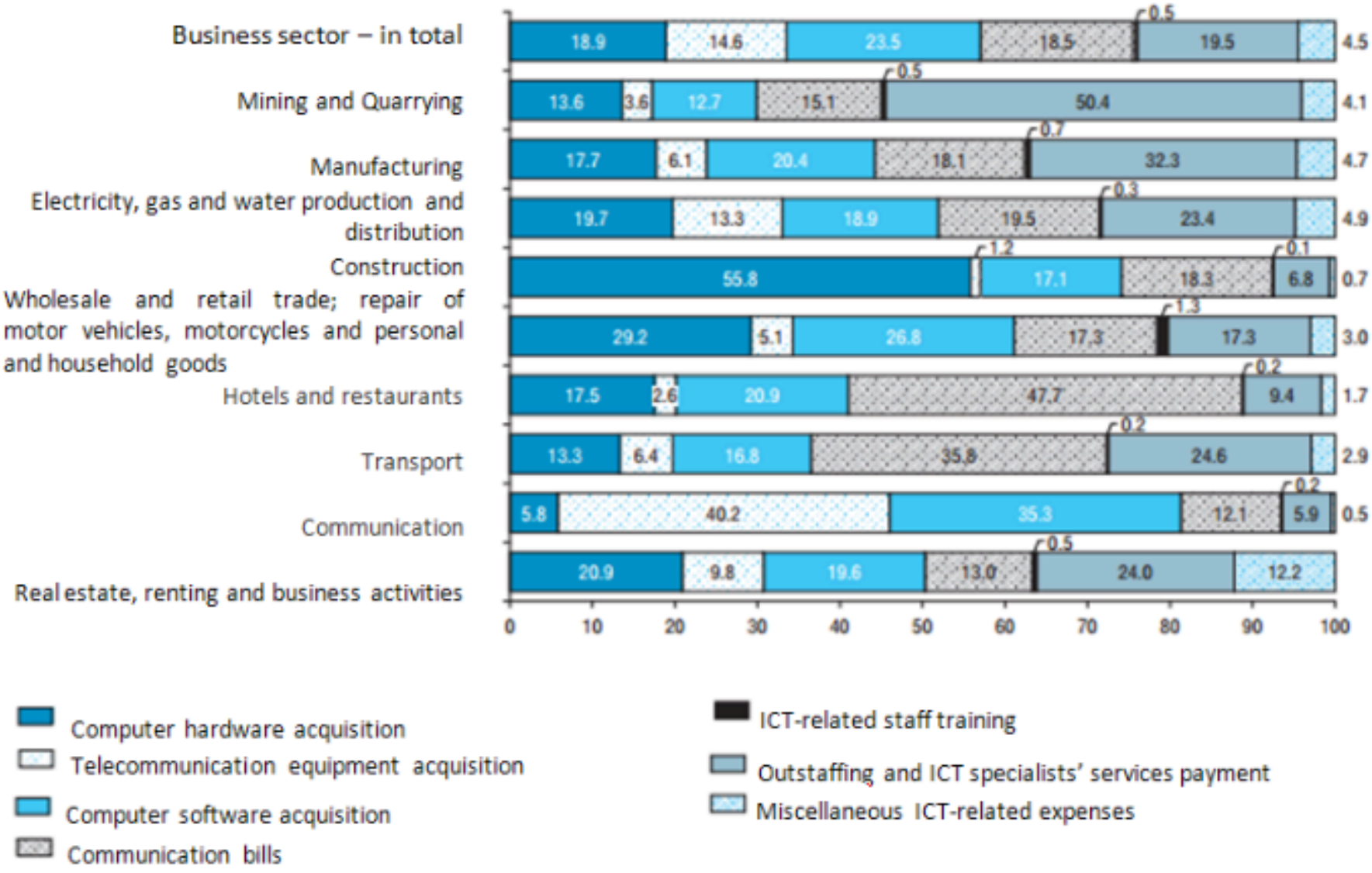
- growth in labor productivity reaches 3% in production management, which is associated with the material support optimization;

- reduction in working time loss by up to 20% through automation of routine processes amenable to standardization and algorithmization, including with application of common software in the field of financial management and accounting;

- reduction in personnel management costs by 7%;

- reduction in logistics cost through optimization of solutions and formation of traffic flows by 7%.

Figure 1
ICT cost structure in organizations by economic activity: 2017



Source: Abdrakhmanova et al., 2018

It should be noted once again that the above achievements became possible owing to the use of generally available standard tools offered by domestic and foreign companies engaged in the hardware and software development. This effect was spread to the construction industry in the Republic of Dagestan, as well.

Analysis of the construction industry management practice shows that optimization of the resource potential management requires using special software developed with regard to the construction specifics, but capable of working in integration with network technologies and design project documentation (Table 2). The goal of introducing IT into the construction industry is to optimize management, procurement and production based on the integrated interaction of information products, enabling to coordinate actions of the company's departments and its partners (contractors) to reduce construction time and costs and improve the quality of the final product (Dzhuliy and Yemchuk, 2015).

Table 2
Use of software in construction organizations in 2017

	Electronic document management systems	Financial calculations in electronic form	Solution of organizational, managerial and economic tasks	Electronic reference and legal systems	Procurement and supply chain management	Access to databases through global information networks
Business sector – in total	62.3	55.4	54.0	51.7	41.9	29.1
Construction	64.2	62.5	57.3	59.9	32.9	26.8

Mental opposition from company managers who do not perceive integrated planning as a technologically solvable task and tend not to increase the cost of acquiring and operating such a product remains the main obstacle to the active introduction of innovative methods from the IT sphere into practice. For many managers, the need to engage IT professionals to work

remains a whim and a waste of money.

According to many managers, planning cannot be effective, since there is a great influence of random and external factors in the construction industry, which means that the costs of its technological support are unnecessary (Adegbile and Sarpong, 2015).

Modern management practices and strategic planning are showing upward trends in the need for real-time data. Planning for the construction enterprise development and production engineering can achieve high performance indicators, subject to timely and competent investment in information technology products.

It is necessary to consider a number of key features of the construction activity for this purpose:

- project-oriented activities, i.e. the specific dependence of the construction industry on the design solution, which is a key element of the product creation process. The use of IT allows integrating management and production operations with the project at a level that forms particularly productive actions and makes it possible to meet the deadlines for preparing the object without loss of quality and dead expenses;

- high risks associated with responsibility for an expensive object, which is practically at the disposal of the construction company, while the successful execution of tasks for one project may cause the development of activities in the future;

- features of information passage and its specificity in the construction industry, where technical, economic and regulatory information is constantly intertwined, creating a rather difficult to interpret picture of events and the state of the enterprise;

- interaction of several organizations of various activities within the holding, which requires to form a system of adequate perception of information and create managerial impulses for related though different processes;

- a high level of dependence of the construction industry on the established state standards from the stage of research and design to the operation of the finished building (Kudinov, 2011a; Trofimova and Trofimov, 2016).

These features can hinder the effective development of the enterprise, but the disclosure of the information resource potential allows using advanced technologies to overcome the contradictions in the complex and achieving high performance in construction.

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3. Results

Specific advanced computer products include CAD and GIS information products, construction cost estimating software, software documentation development systems designed to optimize internal processes and integrate into the existing technological and competitive environment. The use of such programs can significantly improve the efficiency of activities for the disclosure of resource potential, reduce production costs, and optimize the interaction between management and the production process.

The use of Western software products in domestic construction is not always justified – many systems do not take into account the specifics of Russian planning and do not contain internal data on the applicable standards in the field of management, reporting and resource base formation. In addition to the already mentioned psychological features of construction company managers, it is necessary to note external obstacles to the active introduction of information technologies in the construction industry at all stages of the process (Malakhov, 2013):

- the regulatory and legal framework governing the sector activities does not correspond to the current ideas about the application of information technologies in construction, it does not create incentives for innovative development;

- there is a lack of trained qualified personnel resources for management and production activities using innovative optimizing information technologies and the corresponding software product;

- there is no internal management aimed at improving efficiency in construction activities through the use of optimizing technologies and integration into the market and competitive environment at the global level;

- the construction market is fragmented, small companies desire to localize activities within the limited territory with a demand that does not require additional motivation;

- there are no external challenges that dictate the need to revise existing technologies and introduce new operating methods;

- extreme conservatism of the construction sector as such is a phenomenon characteristic of the industry on a global scale, since most of the existing construction companies are engaged in the implementation of model projects, and the scope of activities differ in the number of simultaneously constructed objects with their almost complete similarity.

Opportunities in disclosing the potential of information resources are perfectly realized on the basis of rapid information of exchange systems with the transfer of technological data in a tabular form (Glukhov, 2012). In the modern version it becomes available through the use of cloud services that do not require modifying the document for transmission – it is downloaded directly to a remote server, where it becomes available to a specialist who has the authority to use it: view or edit the data. The exchange of drawing materials and tabular data has been greatly simplified with the introduction and adoption of the FTP server technology, which provide the ability to store large amounts of data with rapid transfer to the console device of a user who has access to the resource. With the proliferation of the Internet access using mobile modems or wireless data transmission technology, such solutions become accessible at the user level. The possibility of using them without special equipment and IT skills, maximum accessibility and availability of option lists provided by after-sales services for corporate customers for a very modest reward is a very important feature of these technologies (Dobrynin et al., 2016; Karyagin, 2017)

Creation of own resource on the Web contributes to the disclosure of the market and competitive potential of the company, and use of self-regulatory organization (SRO) websites makes it possible to establish not only feedback in the corporate and industry environment, but also to form an open control system for the quality of the organization’s services: the SRO website provides information on the company’s compliance with the requirements of the accepted standards. The statutorily introduced practice of electronic trading deserves special mention; it significantly reduced the corruption component in the selection of project executors and increased the transparency of auction activities, enabling the antimonopoly services to timely identify the facts of collusion between customers and project executors. This decision acquired particular importance during the competitive tenders for the execution of government construction projects, since open sites do not allow tendering in the mode of a pre-agreed winning.

Construction companies impose a number of requirements related to the implementation of their own requests with regard to the software products for corporate and internal use:

- the ability to work with calendar schedules with support for hierarchical access to planning;

- the need to create a resource consumption and mobilization schedule;

- the need to create spending plans;

- resource planning;

- situational modeling with the development of action algorithms and “checklists” for changing activity conditions options;

- cost performance analysis;

- corporate and industry integration;

- standardization and rating using remote databases.

The above functions contribute to the growth of efficiency in the disclosure of the general information potential of the enterprise.

On September 17, 2018 it became known about the time frames for the emergence of a single digital platform for construction information systems in Russia. It is created in the framework of the “Digital construction” Federal Project. As part of large-scale digitization major efforts lie ahead of the construction industry:

- to transfer the fund of regulatory and technical construction documentation to digital format,
- to form the basis for the transition to an automated verification of the information model of a capital

construction object,
- to introduce a unified system for construction information classification for harmonizing regulatory and technical documentation with international and Russian legislation.

Digitization of construction involves the automation of all stages and procedures throughout the entire lifecycle of an object. The main requirements for modern construction project management systems include the organization of the common information space for the rapid exchange of information, the connection of work schedule line items with digital model objects and, ultimately, linking to financial systems to close acceptance certificates for payment (Orihuela et al., 2016; Averyanov et al., 2016).

Based on the analysis, a common information space model is proposed for a construction enterprise, developed in accordance with the digital economy matrix (Figure 2).

Figure 2
Common information space model of a construction enterprise

<table>
<tr><td rowspan="11">TECHNOLOGIES</td><td rowspan="2"></td><td colspan="4">CONSTRUCTION ENTERPRISES</td><td rowspan="2"></td><td rowspan="11">DIRECTIONS</td></tr>
<tr><td colspan="2">Macro level</td><td colspan="2">Micro level</td></tr>
<tr><td>Requirements and terminology management</td><td colspan="2">Regulatory compliance</td><td colspan="2">Development of an internal roadmap for informatization</td><td>Setting targets for indicators</td></tr>
<tr><td>e-archive of normative and technical documentation</td><td colspan="2">Amendment of normative and technical documentation</td><td colspan="2">Physical infrastructure formation and staffing support</td><td>Infrastructure and staff preparation</td></tr>
<tr><td>e-procurement</td><td colspan="2">Integrated information system in the field of government and municipal procurement</td><td colspan="2">Project management automation</td><td>Constraint satisfaction and management optimization</td></tr>
<tr><td>e-document flow</td><td colspan="2">Urban Development Support Information System (UDSIS)</td><td colspan="2">Document flow automation</td><td>Document interaction</td></tr>
<tr><td>Data exchange formats</td><td colspan="2">Federal Government Information System for Pricing in Construction</td><td colspan="2">Building Information Modelling</td><td>Elaboration of measures</td></tr>
<tr><td>Process management</td><td colspan="2">Unified State Register of Design Documentation Appraisal Reports of Capital Construction Objects</td><td colspan="2">Automated financial management system</td><td>Risk assessment</td></tr>
<tr><td>Quality assurance</td><td colspan="2">Energy Performance Certificate databases</td><td colspan="2">Automated construction control</td><td>Performance evaluation</td></tr>
<tr><td rowspan="2"></td><td>National institutions</td><td>Professional associations</td><td>Business</td><td>Public organizations</td><td rowspan="2"></td></tr>
<tr><td colspan="4">INSTITUTIONS</td></tr>
</table>

The model defines the main stages of digitization in a construction enterprise at the macro and micro levels, taking into account the technologies and directions envisaged by the digital economy development matrix.

Here, the digital environment of a construction enterprise is considered as a common information space consisting of two elements:

1. Banks of legislative, regulatory, technical and methodological documentation, projects for re-use, standard contracts and other documents to be used by participants in the investment and construction process.

2. Technological platform, which is based on information and analytical systems, information modeling technology and systems ensuring its content and updating by including data from external sources on geological conditions, resources, prices and all changes in the external environment (Kudinov, 2011a; 2011b).

A technique combining the functional completeness method and expert assessments is proposed to form an integrated information system of a construction enterprise and select its elements (Figure 3).

The procedure enables to generate and rank options for creating an information system based on a combination of various components: construction cost estimating, scheduling systems, etc.

At stage 1, it is necessary to determine the target components for inclusion in the generated information system of the construction company.

At stage 2, a group of experts formulate a set of requirements for the consumer quality of the system being created, ranks the list of functional characteristics and determines their weights *Ai*.

Stage 3 and Stage 4 are performed in parallel for each of the IIS options of the construction company. Stage 3 results in several options of the IIS structure for the subsequent selection.

At stage 4, experts estimate the values of the consumer quality characteristics *Gi* for each of the systems. A performance indicator is calculated for each of the alternative IIS options.

$$E(S) = \frac{1}{n}\sum_{i=1}^{n} A_i G_i$$

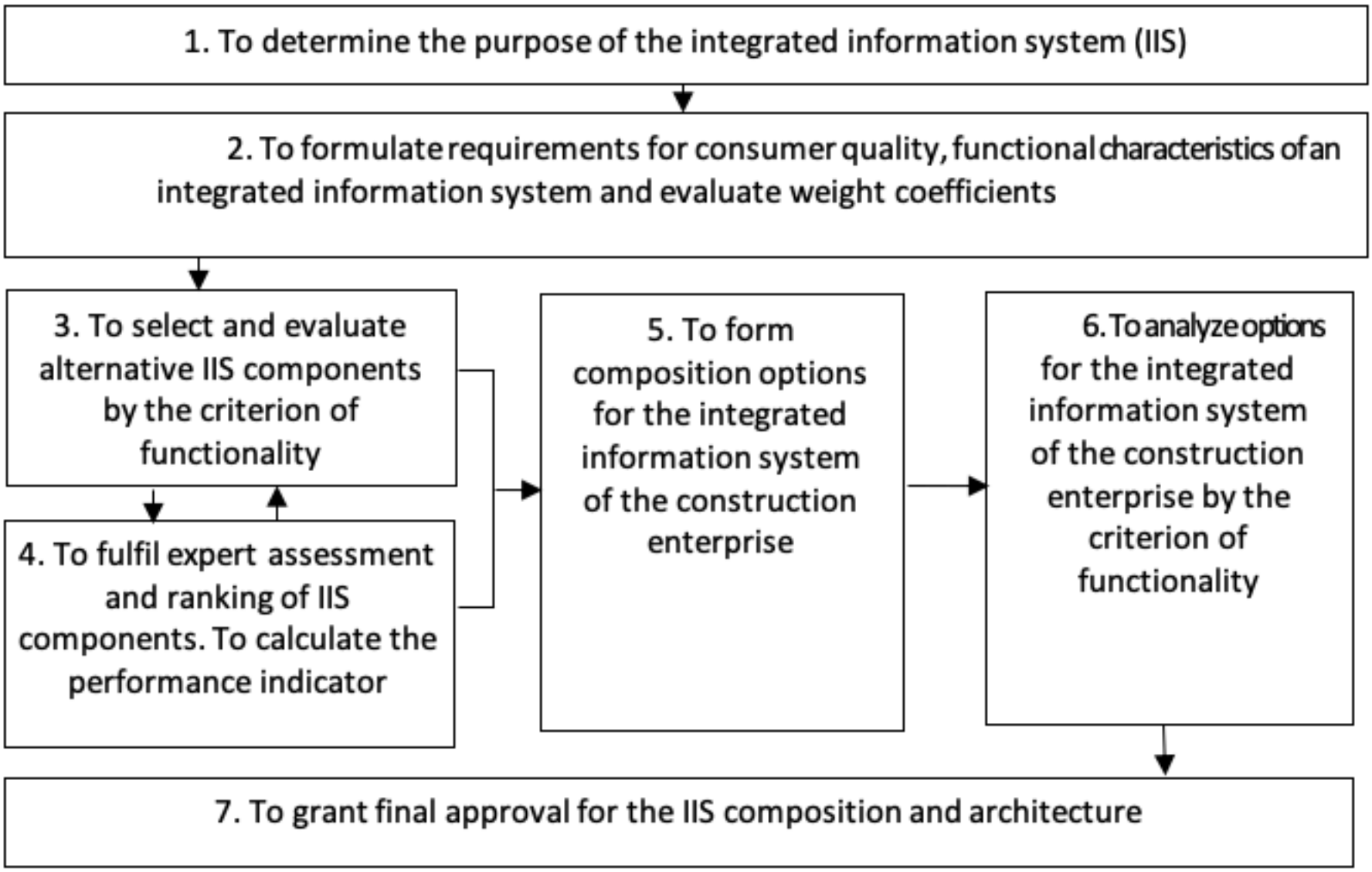
The calculated values of the performance indicator are used to rank the IS components of construction companies.

At stage 5, it is necessary to form a single set of all possible options to build the IS.

At stage 6, a comparative analysis is made of the options for creating an IS of the construction company by the functional completeness criterion.

Stage 7 involves the final ranking of systems using expert methods. Since, as a result of the previous steps, a small number of options remained for IS building, it is possible to compare these systems directly.

Figure 3
A technique for IS component selection in construction companies



The implemented information system should ensure the smooth functioning of the workflow, project management and financial management systems. All three systems form an information solution with common key directories, information flow and users.

The low level of utilization of the potential of the systems themselves remains a problem of introducing modern IT tools into construction practice – often the acquired software is not fully used due to the lack of information about its capabilities, lack of specialists when it comes to using complex software systems (Yudina, 2016).

3.1. Discussion

In our opinion, the introduction of information systems must begin with the automation of workflow. For a construction company, it becomes necessary to automate the control of orders, the front office operation, the archive of documents, and business processes. After analyzing the software products available on the market, it was established that the DIRECTUM information management platform has the most suitable functionality. This is a system to streamline document flow and workflow and to manage business processes, records, financial and accounting operations, projects, etc., providing an increased efficiency of human resources in various areas of joint activities. The DIRECTUM system conforms to the ECM (Enterprise Content Management) concept and supports the full document management lifecycle.

When selecting an automation tool for project management, it is necessary to take into account the specifics of the company’s activities. A transparent, understandable advanced basis should be provided for implementation and management of a large number of projects. In our case, the availability of opportunities for the effective management of the construction company’s resources was the main selection criterion. The Primavera system, which is the standard in the global practice of project management in scheduling, was chosen as such a basis. It is focused on creating a unified corporate project management system. This software is geared toward industry management standards and can be adapted to meet the specific needs of each individual organization (CPA, 2016).

The application of Primavera software will allow a construction enterprise to automatically calculate the critical path, determine the load of resources and help eliminate resource conflicts both within one project and with regard to all the projects being conducted by the company, as well as simultaneously use information resources with the necessary level of detail at all levels

of project management.

When selecting a financial system, it is necessary to take into account the possibility of achieving the desired result in a short time with minimal cost. After analyzing the world and Russian systems, a conclusion was drawn that they all include the similar functional capabilities. When implementing any of them, the user will need time-consuming and complicated work to adjust a budget model, set it up and bring it to use. Taking this into account, the well-known 1C: Enterprise platform is proposed.

Table 3 gives the results of the analysis of information systems for the creation of an integrated information system ensuring the coordinated document flow, project and financial management, and information modeling.

Software systems for construction control cannot be fully developed, because conditions for their implementation are not prepared.

Table 3
Analysis of creating an integrated information system of a construction enterprise by the criterion of functionality

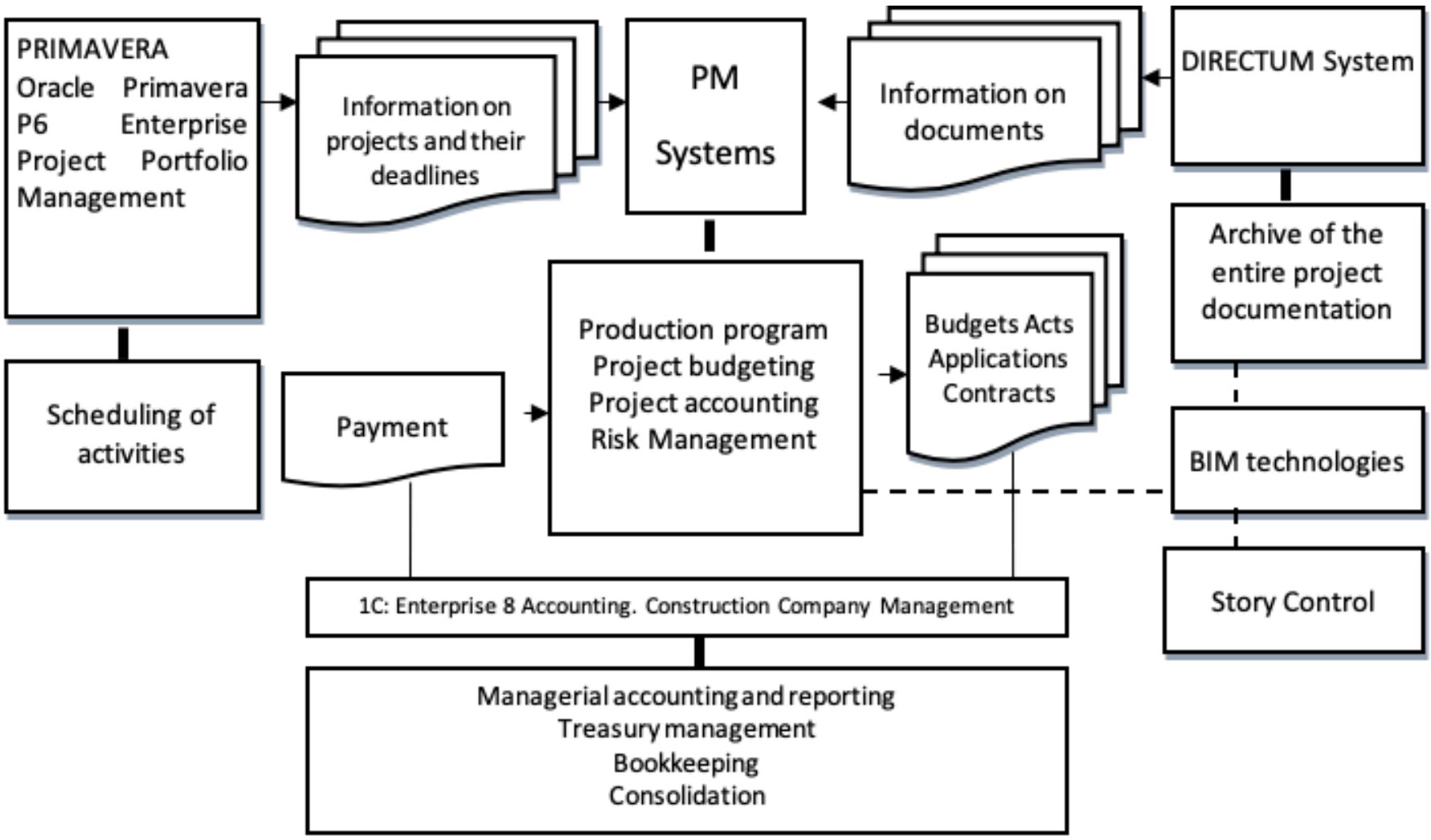
Intended purpose	**System proposed for implementation**	**Required functional capabilities, advantages**	**Possible difficulties in implementation**
Document flow automation	DIRECTUM information management platform	E-document management, business process management, front office and meeting management, customer relationship management, contract management, citizens' and organizations' appeals, performance management	Human factor: habits and unwillingness to change them; fear of being under constant control.
Project management automation	Oracle Primavera P6 Enterprise Project Portfolio Management	Development of a strategically correct set of projects, planning, scheduling and managing large-scale programs and individual projects, resources management, optimal allocation of resources and project progress tracking, monitoring and presenting project implementation reports in relation to the original (target) project schedule, project participants' interaction, integration with management systems, financial flows and human resources	System adjustment for the company's business processes Project entry into the system with reconciliation of all information, which increases the work complexity and timing Employee training in project management principles
Building Information Modeling	BIM technologies, Autodesk Revit Autodesk Autocad	Creation of a concept model of the future object, passing without loss of data to the next stage; Multivariate design; Obtaining a feasibility study; Placing the object of construction in the existing housing development; Submission of the project for consideration to the interested parties; Valuation of options.	Software cost Lack of specialists
Construction control software systems	StroyControl	Subsystem of work with vector CAD-drawings; Operation of the program users in real time, like chat applications - WhatsApp, Telegram and Viber;	The lack of a culture of using business software on smartphones and tablets.

		Ability to work with BIM objects through integration with Autodesk Revit; Bilateral data exchange with other IT-systems.	Fear of data integrity
Financial management automation	1C: Enterprise platform systems: 1C: Enterprise 8 Accounting. Construction Company Management	Bookkeeping and tax accounting Accounting and reporting under IFRS Budget planning Managerial accounting and reporting Treasury management and payment discipline Real estate sales, rental and management records Salaries accounting and human resource management Recognition of assets and structure of the holding entities Integration with adjacent systems	The need to apply the IFRS Chart of Accounts, expanded by the appropriate management profiles, since all systems, including the project management system, must be based on a single chart of accounts

Source: compiled by the authors

At present there is the only Russian company that deals with mobile applications for construction control, Mobile Solutions for Construction, with the StroyControl software package. Currently, a roadmap is being implemented for the implementation of Building Information Modeling technologies at all stages of a capital construction object lifecycle. BIM technologies are based in design on the creation of a three-dimensional building model. BIM technology enables to design a building and even before construction begins to fully calculate and determine all the processes that will occur in it. The authors suggest adapting the well-known architecture for interaction between information systems to implement an integrated information system (Figure 4) (McPartland, 2017).

Figure 4
Scheme of an integrated information system of a construction company



Thus, the construction industry in Russia has a good potential for digitization. The transition to

the digital construction is urgent: despite many adverse factors, a significant number of the most progressive construction companies are introducing new technologies into their operations, seeing their high potential and efficiency. Therefore, the work on the "legalization" of information modeling technologies that has begun at the state level now has great chances for success. And, judging by the government's promulgated plans, the Russian construction industry will finally enter the "digital era" in the next two years. In spite of all the known benefits of using IT in the construction industry, the Russian construction sector suffers insufficient attention to these methods of increasing management and production efficiency. If large companies can afford the organization of local area networks and form a managerial response system, small enterprises are satisfied with purchasing a standard software package for solving accounting and bookkeeping tasks, stopping at what has been achieved. It can be said that the information development potential is extremely high in the construction industry; however, the question is in the possibility of its disclosure, which often rests on the problems that we have mentioned before: the lack of the manager's interest in promoting the company in a competitive environment, satisfaction with the state of affairs, not requiring further development of the company.

4. Conclusions

The authors have analyzed the influence of information technologies on the efficiency of the information potential management in a construction company, the problems and trends in the use of automated management systems in the construction sector, which has made it possible to clarify the areas of information support for managing the resource potential.

In the conditions of transition to "Digital construction", automation of all stages and procedures throughout the entire lifecycle of the facility is assumed. Based on the analysis of the basic requirements for modern information systems in the construction industry, a model of the common information space has been proposed for a construction company, which is developed in accordance with the digital economy matrix.

To form an integrated information system of a construction enterprise and select its elements a technique is proposed that combines the functional completeness method and expert assessments. The technique enables to generate and rank options for creating an integrated information system based on a combination of various components: construction cost estimating, scheduling systems, information modeling, etc.

The analysis of the functional characteristics was carried out and the selection of information systems was substantiated for the formation of an integrated information system for a construction enterprise, which will ensure the efficient operation of the workflow, project management and financial management systems.

The interconnection architecture has been proposed for all information systems to introduce an integrated information system.

The materials of the article are of scientific and practical value for the development of the methodological framework for the implementation of information policy at all levels of the construction industry management.

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