Model organization of enterprise corporate architecture for implementation of integrated management and production of executive documentation in digital format

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***Abstract*—Nowadays, the construction industry is actively implementing digital solutions that support the technological processes of construction and installation works. Particularly relevant is the digitalization of executive documentation preparation. It is a set of documents required to record the construction technology, areas of responsibility in their execution and describes the actual state of the completed project. The process of digitalization of executive documentation is actively stimulated by regulatory enactments.**

Each capital construction facility production has specific requirements for a set of corporate systems and services that support construction activities. Thus, the formation of executive documentation is considered to be one of the multiple business processes of the enterprise. Information for documentation objects creation, as well as the results of executive documentation development should be included in the corporate IT architecture of the organization. It is necessary to ensure the consistency of continuous data transfer between information solutions, their connectivity and relevance. Attention should be paid to compliance with the rules of infrastructure organization and information security of the company to enable users to work in IT systems.

In this paper, the authors present a description of the approach to the organization of the standard configuration of the corporate architecture of a construction enterprise that aims to implement digital solutions for the production of executive documentation in digital format. The processes and data that are produced by information systems to support the processes of construction activities are outlined. Approaches to setting up integrations and organizing data flows of the executive documentation system with existing information solutions are defined. The current limitations and prospects for the development of systems implementation for digital support of construction compliance monitoring processes and executive documentation processing are defined.

***Keywords*— Executive documentation (ED), business process, digitalization, corporate IT architecture.**

I. Introduction

Under modern construction conditions, one of the key aspects is the quality and safety of the work performed in the course of building industrial facilities. However, the processes of control and acceptance of capital construction projects remain complex and demanding. Traditional methods of maintaining executive documentation based on paper and manual checks often lead to delays, errors and malfunctions in the chain of construction processes. There is a need to modernize these processes to make them more efficient, reliable and transparent. The digitalization of construction is stimulated by regulatory and legal acts. A new order of the Ministry of Construction and Utilities of the Russian Federation [1] has already established the possibility of digitizing sets of executive documentation for further transfer to supervisory authorities. The process of documentation transmission through integration with central digital systems of ministries and Rostechnadzor is already planned and implemented in the regions of the Russian Federation [2].

Executive documentation in construction is a set of documents reflecting the actual performance of civil, installation and other works at the site. Maintenance of executive documentation is an important process that ensures quality control, safety and legal protection of the construction process. Correct and timely execution of these documents contributes to the successful completion of construction and commissioning of the facility. The full list of activities within the framework of the given operation is approved by the Urban Planning Code of the Russian Federation [3].

The executive documentation is formed in the process of building control inspection activity authorized by the Urban Development Code of the Russian Federation [4]. Each production of capital construction project has specific requirements for control procedures to accept construction and installation works, the unification of which is necessary at the level of standardization. In 2022 GOST R 70108-2022 [5] was developed, which defines general provisions for the formation and maintenance of executive documentation. It describes the requirements for information systems of electronic document management at construction projects, as well as the characteristics that the documentation should have in digital format. Nevertheless, it does not regulate the description of the stages of construction control inspections during the formation of executive documentation sets.

The executive documentation must also be completed and submitted in the required scope to the supervisory

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authorities of the Russian Federation in order to obtain the relevant permits, for example, a permit to commission the facility. On the basis of document sets, Rostechnadzor checks the recording of work results and quality control of the performance. Order of the Ministry of Construction of the Russian Federation from 16.05.2023 N 344, which came into force on September 1, 2023, defines the requirements for the structure and procedures for maintaining documentation necessary for construction, reconstruction and major repairs for building projects to ensure the quality and safety of construction studies [1].

In connection with the technical exigency, the information system for managing executive documentation should be flexible and universal for application to any type of construction project. The development of a digital tool requires comprehensive analytics to unify the business processes of construction control. Given this requirement, the study highlighted the key activities for recording the results of quality control of construction and installation works, as well as the formation of documentation confirming the preparedness of the facility and its zones for acceptance and transition to the execution of commissioning activities. The key functions to be provided by the system of executive documentation were also highlighted. Based on the comparison of two registers of procedures and parts of functionality, an analysis table was compiled, on the basis of which it is possible to determine whether the information system is sufficient to meet the needs of construction control services of the organization.

Table 1. Characteristics of the required functionality for the executive documentation system

Name of ED system function	Name of business process	Regulatory document
Record the stages and results of construction control inspections	Formation of a request for an acceptance control inspection	SP 48.13330.2019. SP 45.13330.2017 SP 46.13330.2012 SP 520.1325800.2023 SP 433.1325800.2019 SP 129.13330.2019 SP 75.13330.2011 SP 86.13330.2022 SP 70.13330.2012 SP 75.13330.2011 SP 78.13330.2012 SP 71.13330.2017 SNiP 3.01.09-87 SNiP 3.05.05-84 SNiP 3.05.07-85 SNiP 3.05.06-85
	Acceptance control inspection	
	Operational control inspection	
Record the stages and results of inspections of geodetic control	Formation of request for inspection of geodetic control	SP 48.13330.2019 SP 126.13330.2017 SP 45.13330.2017 SP 129.13330.2019 SP 126.13330.2017 SP 86.13330.2022 SP 45.13330.2017 SP 70.13330.2012 SP 78.13330.2012
	Inspection of geodetic control	
Record author's supervision entries	Formation of a request for incoming control inspection	SP 48.13330.2019 SP 433.1325800.2019 SP 520.1325800.2023 SP 129.13330.2019 SP 86.13330.2022 SP 77.13330.2016 SP 76.13330.2016 SP 75.13330.2011 SP 71.13330.2017 SNiP 3.05.05-84 SNiP 3.05.07-85
	Conducting the incoming inspection	
	Verification of supporting documentation for materials and equipment (quality documents, passports, quality certificates)	
Record of author's supervision reports	Request for involvement of a supervision specialist	SP 48.13330.2019. SNiP 3.01.09-87
	Author's supervision and registration of resolutions	
Maintaining a general log of works	Registration of the general work log at the regional office of the supervisory authority	
	Registration of operational fact of construction and assembly works execution	
Generation of elements of executive documentation based on the results of construction control inspections	Generation and signing of certificates (Certificate of Approval of Construction-in-Place, Certificate of Approval of Concealed Works)	
	Formation of object description as-built	
	Record of works results in special study logs	
Generation of elements of executive documentation based on the results of geodetic control inspections	Coordination of executive schemes	GOST 51872-2019 SP 126.13330.2017 SP 48.13330.2019.
	Generation of object description as-built	
	Record the results of construction and installation works in special work logs	
Generation of elements of executive documentation based on the results of incoming control inspections	Generation and signing of incoming inspection certificates	SP 48.13330.2019.
	Generation and maintenance of the log of incoming inspection	
Record the stages and results of testing	Laboratory testing of materials	SP 75.13330.2011 SP 86.13330.2022 SP 72.13330.2016 SP 77.13330.2016 SP 76.13330.2016 SP 75.13330.2011 SNiP 3.05.07-85 SNiP 3.05.06-85 SNiP 3.04.03-85 SP 48.13330.2019.
	Non-Destructive Testing (NDT)	
	Destructive Testing (DT)	
	Pre-Commissioning Phase (PCP) Tests	
Preparation of a report on the results of the tests	Registration of NDC laboratory test results	
	Registration of DT laboratory test results	
	Registration of the results of the PCP tests	
Registration of remarks	Record of remarks identified during inspections regarding the quality of construction and assembly work or the quality of materials and equipment	SP 48.13330.2019.
Registration of prescriptions	Issuing prescriptions for the remarks identified during inspections	
Generation of sets of executive documentation	Generation and signing of executive documentation set	GOST 70108-2022 SNiP 3.01.04-87 SP 68.13330.2017

II. DESCRIPTION OF A MODEL ARCHITECTURE OF INFORMATION SYSTEMS IN A CONSTRUCTION ORGANIZATION

Contemporary construction organizations face a multitude of challenges that require integration and synchronization of

various services and systems for effective project management. The process of enterprise system architecture specification aims to ensure standardization, optimization, and improved course of data handling to ensure the accuracy, availability, and timeliness of information at all stages of the construction project lifecycle. This chapter describes the unified solutions that are used by construction organizations to support key business operations.

With digital modeling in construction, effective management of engineering data is a crucial aspect. For this purpose, specialized engineering data management systems (EDMS) are used to provide centralized storage, processing and management of project information. An EDMS standardizes and optimizes the entire data management, improving data availability and accuracy, which is especially important for large construction projects.

EDMS is used to control engineering data, including documentation, at all stages of the project life cycle - from initial design to completion of construction and subsequent operation of facilities. The main purpose of using the system in construction organizations is centralized storage of all types of data and documents with engineering description of the object. In its turn, the information solution allows to control versions and history of changes in design, operational and engineering documentation. This makes it possible to synchronize the documentary description of the construction object with the actual physical location of construction elements and installed equipment. Constant update of construction project data and keeping it current makes it possible to ensure the regular work of operational services, as well as repair and maintenance departments of the facility in service. Searching for information on the construction project after it is put into operation with the use of EDMS becomes more convenient and efficient. In addition, the engineering data management system provides advanced analytical and reporting capabilities, which allows to obtain insights from data, identify trends and make reasoned decisions for construction projects, as well as during their further operation [6].

To support the course of work, the engineering data system is loaded with design and engineering documents, drawings, specifications, estimates, 3D models of equipment elements and other types of technical information. This data can come in a variety of formats, including electronic and paper copies, which are then digitized and structured in the system. The output of the EDMS provides access to the current version of each document, generates reports on the status of projects, generates analytical data and provides version control, storing the history of changes for each element of building structures. Integration with computer-aided design systems, computer-aided engineering (CAE) systems, and a unified project management system can be configured to transmit and receive data and data objects [7].

The source of technical documentation can be a technical electronic document management system. It provides effective management and control of engineering drawings and accompanying documentation at all stages of the construction project life cycle. The main purpose of implementing such a system is to increase the efficiency of work with documents, reduce the risk of human error and improve coordination between different departments at the construction site. Technical document management allows to standardize the processes of design documentation work.

The technical document management system receives project documentation in the format of drawings, schemes, equipment specifications, certificates of conformity and technical data sheets. The result of project documentation aggregation is the creation of a centralized storage and archive for the construction project. All documents are stored in a single database, this ensures their availability to authorized employees of the company. The system tracks changes in documents, which allows persons performing and accepting construction and installation works to use actual versions of design, working and design documentation. The processes of coordination, approval and archiving of documents provided by project design organizations are also automated, which significantly accelerates the work on approval of final sets of working drawings [8].

An effective technical document management system helps to reduce paper costs and ensure that the production processes of developing sets of working drawings and design documentation are connected, which is especially important in the active construction phase, where speed and accuracy of working with information are key success factors. Implementation of such a system requires thorough preparation and analysis of current business processes of the organization responsible for design and survey works, as well as expertise of author's supervision. The technical document management system can integrate with other corporate systems such as engineering data management system as well as construction project management system to ensure seamless interaction and data exchange.

Network scheduling plays a critical role in construction projects because it enables effective project management, minimizing risk and ensuring that work is delivered on time and within budget. It is a tool for creating a detailed schedule for a construction project that takes into account the sequence of works, resources and time constraints. The main objectives of network scheduling are to develop a detailed grid model of the construction project by determining the critical path, to establish the sequence of works and their dependencies, and to estimate the duration of each construction phase. To create a network schedule, information about the project, resources and time constraints is required. This information includes information about the project, including its scope, and information about resources, their availability and allocation. In addition, historical data on similar projects, expert judgment, and information on potential risks and uncertainties are needed. This information should be updated regularly to reflect changes in the project and the network scheduling should be optimized [9].

The network scheduling system (NSS) is a key tool in construction project management. It is necessary to create detailed work schedules in digital form, which help to coordinate the actions of different departments and contractors. The main goal of this system is to ensure that all project phases are completed on time, minimizing downtime and delays. To make strategic decisions, the construction

project management can generate progress reports that allow tracking and identifying possible deviations from the plan. The functionality of the system allows building forecasts and scenarios for the development of the construction process, taking into account various factors and risks. Due to integration with other enterprise systems, the NSS provides an accurate and up-to-date view of the project status, which contributes to the timely execution of works and achievement of targets [10].

A procurement management system (PMS) is required to effectively plan, control and manage the supply of materials and equipment. It minimizes construction delays, optimizes costs and improves overall project productivity. A PM system ensures that all required resources are available at the right time and place, which is critical to the successful completion of a construction project. Based on design data and construction schedules, purchase requisitions are generated that take into account current inventory and future needs. A procurement management system plays a key role in the successful completion of construction projects. It ensures effective planning and management of material deliveries, minimizing the risks of delays and overruns [11].

Integration with other enterprise information systems is required for the purpose of the pm system performance. It is loaded with material and equipment specifications, information on planned dates of the network schedule, contracts and documentation of procurement activities. This data is used to generate purchase requisitions, plan deliveries and control order fulfillment. In turn, the reporting produced by the system provides insight into the inventory balance of material items, as well as the quantity and location of materials in stock, order status, and expected deliveries. Analytical data aids in decision-making, including demand forecasts, cost analysis, and supply performance evaluation. Information on the quality and compliance of materials to standards enables timely quality inspections and identification of product defects. The system can also be used as a source of information to manage logistics and resource allocation between construction sites.

The economic accounting system for construction projects is an important element of the company's IT infrastructure. This system is used for integrated management of financial flows, accounting of costs and revenues associated with each project. Its main purpose is to provide control of financial transactions, optimize costs and improve the efficiency of financial management. The system is loaded with data on all financial transactions, including material costs, labor costs, costs of trades with counterparties and other expense items. At the output, the solution provides reports that allow you to analyze the profitability of projects, identify inefficient expenses and make funding forecasts. In this way, economic accounting supports a set of business processes, such as budget planning, cost control and financial reporting in a construction project. The economic accounting system can be integrated with other systems in the organization, such as the logistics management system and the network scheduling system. This allows for automatic data exchange, for example, information on materials purchased or studies performed is automatically reflected in accounting, minimizing the risk of errors and simplifying the reporting process. In addition, data from the technical workflow system can be used to clarify costs associated with estimate documentation, which helps improve financial control [12].

Project Management Information System (PMIS) is a tool that helps enterprises to effectively manage project assets, optimize the use of resources and achieve strategic goals. The main objective of a PMIS is to create a single space for monitoring, planning and evaluation of all active projects, which enables effective mitigation and risk management.

For construction projects, a project management system is used to monitor construction sites and other construction and installation works from initiation to completion. It integrates data from various sources to provide a comprehensive view of the current status of projects. The system helps to identify development priorities among the organization's assets. To do this, the PMIS receives data on construction projects, including timelines, budgets, resources, and key performance indicators. Users receive generated reports and analytical forms that allow management to make informed decisions about construction progress. The interconnection of the IPMS system with other existing software in the company's IT architecture also plays an important role. Integration with the network scheduling system allows synchronization of study schedules, while interaction with the system of economic accounting and PMS provides actual information on financial costs and allows controlling resource consumption. Thus, the PMIS system becomes a key tool for managing construction projects in the organization, providing an integrated approach to their implementation and allowing the enterprise to successfully achieve its objectives [13].

Cost estimate documentation is an important element of a construction project because it allows the customer and contractor to determine the contract price, which is necessary for cost planning and cost analysis at all stages of construction. The content and scope of the cost estimate documentation are determined by regulatory acts, such as the Russian Government Resolution No. 87, as well as various instructions and methodological recommendations at the level of the organization [14]. The development of documents passes through several stages: pre-project, design and working document stages. This allows to clarify the estimated values at each stage and provide detailed costs.

The system designed for work with cost estimate documentation is intended for automation of formation, storage and processing of cost estimates in construction projects. It allows to create documents of estimates for construction and installation works, design and additional expenses. One of the key functions of the system is automatic updating of current rates and norms, which greatly simplifies the process of preparing financially significant documentation. Several types of data must be loaded for the system to function. These are project documentation, cost estimates and local estimates, which provide initial parameters for calculations. Current rates and regulatory documents that help determine the cost of various construction works are also required. Generating estimates, in turn, requires data on materials and resources, as well as technological processes that are necessary to perform

construction tasks. At the same time, the system produces cost estimates for different types of works, cost reports and variance analysis from planned costs. Thus, the estimating system supports important business processes, including preparation and adjustment of cost specifications, accounting and control of construction expenditures. Integration with other systems such as engineering data management, procurement and accounting provides quick access to necessary information and contributes to the efficiency of project management [15].

Such a set of services allows minimizing risks associated with human factor, ensuring synchronization and updating of data, as well as increasing the overall efficiency and productivity of construction projects. Integration and interrelation of these systems provide the opportunity to obtain comprehensive and relevant information, which contributes to informed decisions and successful implementation of all stages of the construction project.

To form a description of a model architecture for a construction organization, the key functions and data operated by a standard set of construction services have been studied and described. Each of them provides the functionality of a adjacent IT-solution. Thus, the data flows exchanged between the enterprise systems on integration were identified and described. These are summarized in the table below.

Table 2. Integration data flows in a model IT-architecture of a construction organization

ID Data Flow	Data description	Source system	Receiving system
ID1.1	Transfer of project documentation data and files	TDMS	EDMS
ID1.2	Transfer of data and files of working documentation	TDMS	EDMS
ID1.2	Transfer of data and files of working and design documentation	TDMS	EDMS
ID1.4	Transfer of data and files of local cost estimates	TDMS	SCED
ID1.5	Transfer of data and files of cost estimates	TDMS	SCED
ID1.6	Transfer of information on completion of the stages of the development and approval of the design and engineering survey results	TDMS	EAS
ID2.1	Transfer of data on lots for procurement of construction and installation works	SCED	EAS
ID2.2	Transfer of price calculations for lots for procurement of construction and installation works	SCED	EAS
ID2.3	Transfer of data and files of KS-2 statements	SCED	EAS
ID2.4	Transfer of data and files of KS-3 statements	SCED	EAS
ID3.1	Transfer of data and files of quality documents and passports for materials and equipment	PMS	EDMS
ID3.2	Transfer the fact of delivery and acceptance of materials and equipment for construction and installation works	PMS	EAS
ID3.3	Actual involvement of materials in construction and installation works (quantity data)	PMS	PMIS
ID3.4	Actual involvement of materials in construction and installation works (data on dates and quantities)	PMS	NSS
ID4.1	Data for the 1st level of the network schedule	PMIS	NSS
ID4.2	Data for the 2nd level of the network schedule	PMIS	NSS
ID4.3	Contracts with counterparties (deliveries)	PMIS	УМТР
ID5.1	Data of the redesigned 1st level of the network schedule	NSS	EAS
ID5.2	Data of the developed 3rd level of the network schedule	NSS	PMIS
ID5.3	Data of the developed 4th level of the network schedule	NSS	PMIS
ID5.4	Modifications made for the 3rd level of the network schedule	NSS	PMIS
ID5.5	Modifications made to the 4th level of the network schedule	NSS	PMIS
ID6.1	Data on procurement and supply of materials and equipment for the 3rd level of the network schedule (procurement volume)	EAS	PMS
ID6.2	Data on procurement and supply of materials and equipment for the 4th level of the network schedule (procurement volume)	EAS	PMS
ID6.3	Data on procurement and supply of materials and equipment for the 3rd level of the network schedule (dates of procurement and supply)	EAS	NSS
ID6.4	Data on procurement and supply of materials and equipment for the 4th level of the network schedule (dates of procurement and supply)	EAS	NSS
ID6.5	Purchase price of materials and equipment for construction and installation works	EAS	PMIS
ID6.6	Data on calculations of	EAS	PMIS

	planned labor costs		
ID6.7	Data on actual labor costs (terms)	EAS	PMIS
ID6.8	Data on actual labor costs (timing and volumes)	EAS	NSS
ID6.9	Completion of construction and erection phases (timing)	EAS	PMIS
ID6.10	Completion of construction and erection phases (timing and volumes)	EAS	NSS
ID6.11	Contracts with counterparties (construction and supply)	EAS	PMIS

The inter-system interaction between the unified solutions used, as well as their communication by means of organized data flows can be represented graphically. The description is presented in the image below.

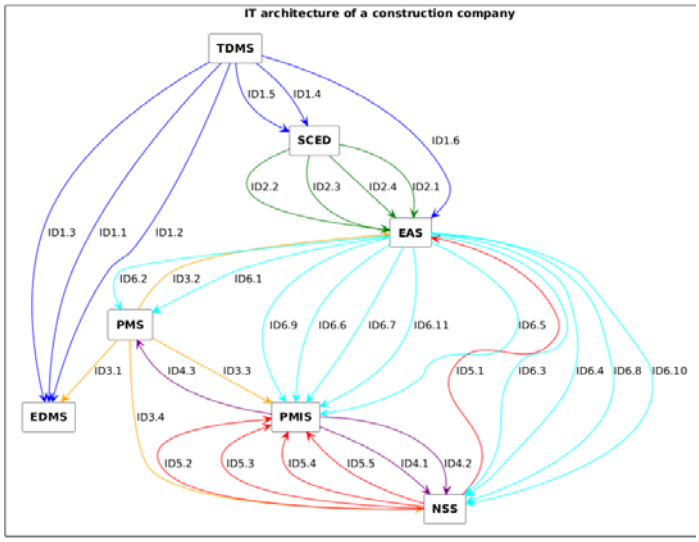

Figure 1. Model architecture of construction organization systems

The following descriptive values were used:

- EDMS - Engineering Data Management System
- TDMS - Technical Electronic Document Management System
- NSS - Network Scheduling System
- SCED - System of cost estimate documentation development
- PMS - Procurement management system
- EAS - Economic accounting system
- PMIS - Project Management Information System

III INTRODUCTION OF THE EXECUTIVE DOCUMENTATION SYSTEM INTO THE MODEL IT-ARCHITECTURE

To implement the executive documentation system into the previously described model model IT architecture of a construction organization, it is necessary to develop a phased plan. Such a process with testing at each stage ensures that problems are identified and eliminated before the system is fully launched, which reduces the likelihood of downtime and errors in study.

A step-by-step approach is worth starting with preparation, which will involve analyzing the current business processes associated with records management at the enterprise. The inspection activities should be investigated in turn and the phases at which the employees involved in the construction project will interact with the system of executive documentation should be determined. After identifying the key requirements for the system, it is necessary to compare them with regulatory documents and internal standards of the organization. The result of the preparatory activities will be the substantiation of the IT-solution selected for implementation and the prepared terms of references for revision.

At the next stage the software for the executive documentation system is developed or adapted with the help of the analysis results. This process may include customization of existing solutions or development of new software that takes into account the specifics of the organization and legislative requirements. The deployment of production environments, applications and databases requires a set of changes to the enterprise infrastructure. Conversely, the system must be configured to collect metrics from its components to monitor the health of the system elements. The result of these changes should be a functional pilot version of the executive documentation system, the evaluation of which can be carried out within the framework of experimental industrial operation based on the results of initial user testing.

The next most time-consuming stage is the customization of the implemented system with already available information solutions to support construction processes. During this period, it is necessary to ensure the appearance and setup of data and file transfer to ensure seamless work of the executive documentation system. It is also important not to disrupt the data flows between corporate systems already established in the company. Thus, the integration setup should first be performed on an isolated test environment to check the correctness of interaction of the executive documentation system with other IT solutions. In turn, program interfaces (APIs) and data exchange protocol settings should be tested and debugged. The optimal outcome is to conduct a pilot project at a real construction site to verify the operability of integration and correct any identified deficiencies.

At the end of the implementation project, user training and adaptation is carried out with the help of experts from the vendor organization or employees of the company that provided the development in-house. Any format of competence transfer can be defined, from holding training seminars and workshops for employees who will operate the new system to preparation of instructions and description of key functionality in user and administrator manuals. This is important to ensure a smooth transition to the new system and minimize operational mistakes.

At the end of the implementation process, the executive documentation system should enter the stage of industrial operation. [16]. To transition to full use of the system, the customer of the new software must conduct the final stage of acceptance testing for the entire scope of the developed functionality. In turn, the IT solution should be tested for information security settings and infrastructure settings validity. The solution should be handed over for support to

the specialized function represented by the corporate systems operation and technical support team. At this stage, the system's continuous performance is monitored and regular software updates and maintenance are conducted.

However, in the process of implementing an executive documentation system, the customer organization may face a number of difficulties and constraints. For example, employees may be reluctant to switch to new processes and systems, which requires additional training and motivation efforts. Also, when configuring the inter-system interaction of a new IT-solution with existing ones in the typical enterprise architecture, there may be technical difficulties in integrating with legacy or incompatible systems, which will require additional resources for adaptation and customization. Integration of different systems increases the risks of data leaks and requires enhanced information protection. Maintenance of the system and its components requires regular updates and adjustments, which may require additional time and resources. Thus, detailed planning and phased implementation of the executive documentation system, taking into account all possible risks and problems, are the key to successful project realization and achievement of the set goals.

Integration of the system of executive documentation (SED) with various systems in the construction organization is necessary to optimize processes, increase their transparency, accuracy and speed of execution. To organize inter-system interaction, the systems with which the new IT-solution needs to exchange data have also been identified. Integration of the executive documentation system with the engineering data management system allows to automatically receive updated drawings, specifications and other important documents to update the description of the object under construction. Technical electronic document management automates the process of exchanging drawings between various departments and external contractors. Integration with TDMS allows to significantly accelerate the process of transferring design, working and design documentation to construction supervision and construction contractors. TDMS is also an archive repository for ready sets of executive documentation. Integration with the PMS system allows the system of executive documentation to receive data on the availability and use of materials, which contributes to accurate accounting and control of resources required for construction studies. In turn, warehouse accounting requires information on the volume of materials and equipment units involved in construction and installation works. In order to fix the volume of work, as well as to keep a general log of works, SED must receive information about unit rates for works, which are formed in the system of cost estimate documentation and installation cost calculation. This system is also responsible for the formation of primary documentation, on the basis of which the settlement with contractors is realized. Thus, from the system of executive documentation it should receive the data necessary for formation of KS-2 and KS-3 statements [17]. In the system of network scheduling it is also necessary to transfer data on the beginning and completion of works, for which the operational fact is registered daily. From the Project management system to the system of executive documentation it is necessary to transfer information on contracts with subcontractors to ensure control and legitimacy of the work and the use of materials in construction and installation activities.

The already existing register of integration flows in the model architecture of construction services should be supplemented with the positions that appeared in connection with the introduction of the executive documentation system. They are presented in the table below.

Table 3. Integration data flows in a model IT-architecture of a construction organization

ID Data Flow	Data description	Source system	Receiving system
ID7.1	Construction site data as-built	SED	EDMS
ID7.2	Data and files of executive documentation sets	SED	EDMS
ID7.1	Construction site data as-built	SED	TDMS
ID7.2	Data and files of executive documentation sets	SED	TDMS
ID7.3	Requests from the site for author's supervision	SED	TDMS
ID7.4	Data on accepted physical volumes	SED	SCED
ID7.5	Data on the fact of involvement of procurement	SED	PMS
ID7.6	Data of KS-6 (general log of works)	SED	NSS
ID7.7	Data on inspections performed	SED	SCED
ID1.7	Transfer of project documentation data and files	TDMS	SED
ID1.8	Transfer of data and files of working documentation	TDMS	SED
ID1.9	Transfer of data and files of design documentation	TDMS	SED
ID2.5	Data on unit rates	SCED	SED
ID3.5	Data on materials and equipment	PMS	SED
ID3.1	Transfer of data and files of quality documents and passports for materials and equipment	PMS	SED
ID4.3	Contracts with contractors (supplies)	PMIS	SED
ID4.4	Contracts with contractors (construction and installation)	PMIS	SED

Thus, the target architecture of building services can be described by the following scheme.

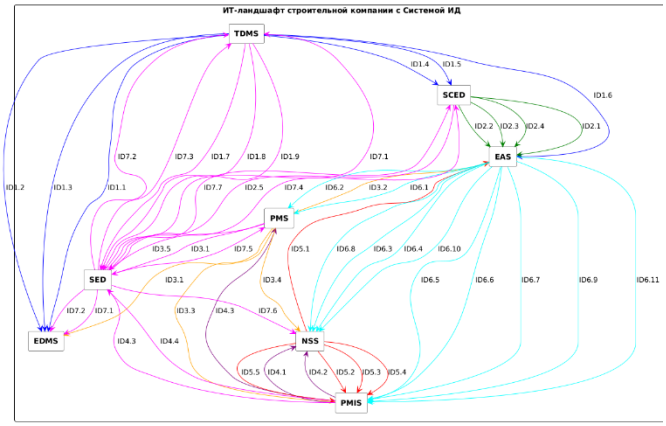

Figure 2. Architecture of corporate construction services with executive documentation system

The following descriptive values were used:

- EDMS - Engineering Data Management System
- TDMS - Technical Electronic Document Management System
- NSS - Network Scheduling System
- SCED - System of cost estimate documentation development
- PMS - Procurement management system
- EAS - Economic accounting system
- PMIS - Project Management Information System
- SED - Executive documentation system

IV. Discussion on current constraints

According to the updated provisions of the Order of the Ministry of Construction of the Russian Federation dated 16.05.2023 N 344/PR, the requirements to the format of maintenance of executive documentation are defined, namely, the reference to the possibility to conduct it in a fully digital format [1]. The documents may be kept on paper or in electronic format, without duplication on paper. Due to the previously described and confirmed possibility of transferring business processes of control procedures and formation of inspection artifacts in digital form, a large number of organizations are already actively implementing profile information systems. However, there are a number of limitations for a complete transition to the maintenance of executive documentation and recording of inspection activities in electronic form.

Among them is the requirement to affix an enhanced non-qualified or qualified electronic signature to the prepared executive documentation. Thus, there is a need to issue certificates and keys of electronic signatures for all parties involved in the process of forming and coordinating sets of documents. In turn, an electronic document management system or a specialized IT-solution for the formation of executive documentation and recording the results of inspection activities should be able to interact with a certification center to verify active signatures and confirm their validity. The optimal solution is to set up integration with the crypto-provider software, which will allow to perform signature validation operations within the corporate circuit of the enterprise. This approach is fully capable of satisfying organizations' information security policies [18].

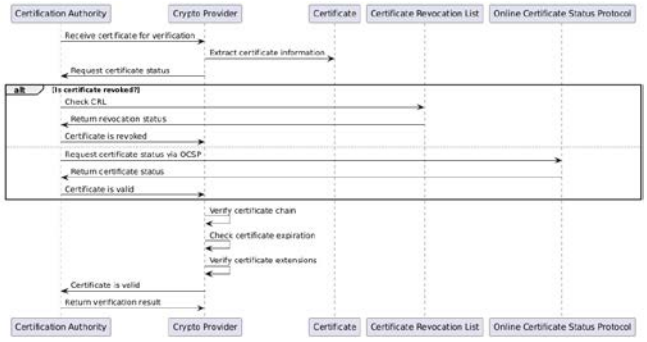

Figure 3. Integration scheme for providing an enhanced qualified signature

It is worth mentioning that in accordance with the legislation the documents of executive documentation are certified by signatures of all participants of the survey, including employees of external contracting organizations that do not have access to corporate systems of the customer organization. The process of providing access to the corporate data transmission network is time-consuming and may be suspended by the information security service due to the risk of corporate data leakage due to negligent actions or faults of external users. The enterprise needs to provide for mechanisms of interaction of counterparties with electronic services.

Also, in accordance with Federal Law No. 536-FZ of 19.12.2022, the use of a machine-readable power of attorney is mandatory for the use of a qualified electronic signature from September 1, 2023 [19, 20]. Authorized representatives of contracting organizations, as well as individuals performing a number of services, will be obliged to use machine-readable power of attorney to sign electronic documents, including executive documentation. This format avoids the need to submit paper powers of attorney and have them notarized. It is required that employees involved in the preparation of executive documentation and inspections have separate electronic signature certificates. Documents are signed using this signature, and the application of the machine-readable power of attorney to electronic documents ensures their legal significance. On September 1, 2024, new requirements for the use of an electronic qualified signature go into effect, requiring that a signature belonging to an individual employee be backed by its own power of attorney.

The alternative is to use an enhanced non-qualified electronic signature, already authorized and recommended for signing electronic executive documentation. An external organization can independently provide its employees with this type of electronic signature by issuing a signature in the "Gosuslugy" Internet reference and information portal [21].

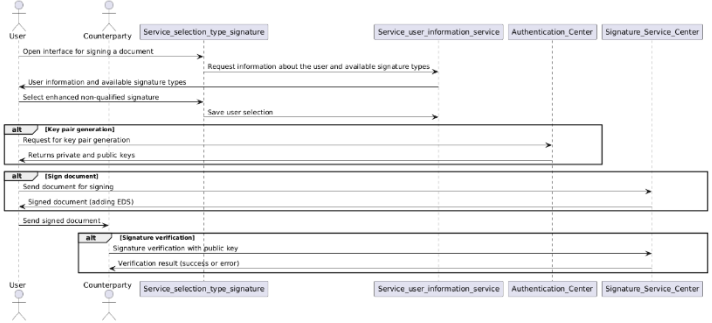

Figure 4. Integration scheme for providing an enhanced unqualified signature

The introduction of digital technologies into construction supervision in Russia is an urgent challenge that requires significant changes in existing document management processes. In order to switch to digital maintenance of executive documentation, it is necessary not only to create documents within the company in electronic format, but also to ensure their transfer in electronic version to state supervisory authorities. Currently, this task faces a number of limitations, including those related to the readiness of information systems of supervisory authorities and their full-scale implementation.

Despite the current limitations, the prospects for the development of digital technologies in construction supervision in Russia are quite encouraging. The national program “Digital Economy of the Russian Federation” provides for the introduction of modern information technologies, such as information modeling technologies, distributed registry systems, big data processing and artificial intelligence. These technologies should ensure more efficient management of construction projects and increase the transparency of construction supervision processes.

Rostechnadzor already uses two main systems to record activities in the field of state construction supervision. Among them are VIS GSN (Departmental Information System of State Construction Supervision) and GIS TOR KND (State Information System of Territorial Bodies of Rosreestr for Cadastral and Real Estate Affairs). VIS GSN is designed to automate the processes of state construction supervision, including registration of facilities, conducting inspections and reporting. It provides an opportunity to store and analyze data on construction objects, which improves control over compliance with construction norms and rules. GIS TOR KND is used to manage data on cadastral objects and real estate. It provides access to information on real estate rights and cadastral value of objects, which is important for construction supervision and recording of changes in real estate [22]

Each region of the Russian Federation implements its own information systems, which creates difficulties for their integration with federal systems. These local programs are developed taking into account regional peculiarities and requirements, which makes them unique and complicates the unification of data transfer processes. One of the main problems is the lack of a single standard for integrating regional systems with federal systems. This leads to the need to finalize and adapt each system to specific conditions, which requires additional resources and time. In addition, many regional systems are not yet ready for full transition to electronic document management and require significant improvements.

Some construction organizations actively use GISOGD (State Information System for Urban Planning), which is a specialized platform designed to automate and improve processes in the field of urban planning. GISOGD ensures the transition to electronic document management, which significantly improves the efficiency of the study of state bodies and participants in urban planning activities. The system is used to accumulate, store, process and analyze information related to construction objects, including cadastral, planning and design documentation. It allows to provide open access to information for participants of urban planning activities and the general public.

GISOGD is used by different levels of government to fulfill their authorities in the sphere of urban planning and land relations. The main users of the system are the Ministry of Construction of Russia, Rostechnadzor, Rosreestr, Regional executive authorities, Local administrations, which perform urban planning and supervision functions in their regions. The system provides tools to monitor and control the implementation of construction studies and compliance with building codes and regulations. This includes automatic notification of violations and the possibility of remote inspections. The system provides for the transfer of executive documentation in electronic form between various public authorities and construction participants. This allows to speed up the processes of coordination, verification and approval of documents [23].

In turn, the Ministry of Construction and Housing and Communal Services of the Russian Federation is developing a Project Management Information System (PMIS), which should become the central platform for construction project management and document management at the federal level. However, at the moment, the PMIS is at the development stage and is not ready for full implementation. It is expected that full integration of all regional systems with the federal PMIS system will be completed not earlier than 2030. This timeframe is due to the complexity of the tasks and the need for significant investment in the development and implementation of new technologies. The implementation of the program also provides for the use of software of domestic origin, which should contribute to the development of the national IT-industry and reduce dependence on foreign technologies [2].

However, it is possible to tentatively design a target vision for the interaction between public authority systems as well as the corporate executive documentation system. Based on the conducted research, a graphical description was made, presented below.

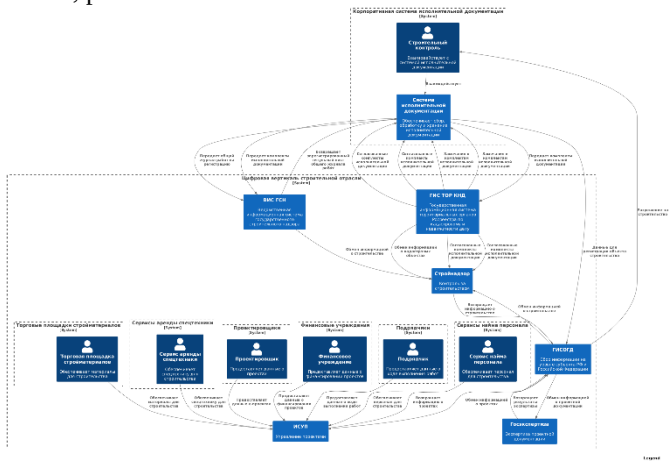

Figure 5. Targeted cooperation of the corporate system of executive documentation with information systems of supervisory authorities

In conclusion, it should be noted that the transition to digital maintenance of executive documentation in electronic format requires not only technical solutions, but also significant organizational changes. It is necessary to

develop common standards and methodologies for the integration of various information systems, as well as constant updating and refining of existing platforms. Only with a comprehensive approach to solving these tasks can we achieve successful implementation of digital technologies in the sphere of construction supervision in Russia.

IV. CONCLUSION

In this research article the topic of implementation of executive documentation system (SED) in IT-architecture of construction services was considered. It is important to note that executive documentation is a set of documents that confirm the compliance of completed construction studies with design documentation and construction standards. Executive documentation is necessary to control the quality of construction and compliance with all established standards. Implementation of the executive documentation system is an urgent and priority goal for construction organizations. The system of executive documentation supports various business processes. Among them we can highlight the maintenance and storage of documentation, automation of inspections and approvals, change management, control over compliance with building codes and standards, as well as interaction with government agencies. With the rapid growth of requirements to the accuracy and completeness of executive documentation, the introduction of SED allows to automate the process of its maintenance, reduce the risk of errors, increase transparency and efficiency of the work.

First of all, the financial costs of implementing SED should be noted. This includes the cost of purchasing and configuring software, updating or modernizing IT-infrastructure, staff training and system support. In addition, significant costs may be associated with integrating SED with existing information systems, such as project management systems, estimating and procurement systems. However, this initial investment can be justified by significantly reducing operating costs and improving performance of the constraction projects in the long term.

Risks associated with executive documentation system implementation include technical and organizational aspects. At the technical level, the main risks are related to possible system failures, data transmission disruptions and information security issues. To minimize these risks, it is necessary to carefully plan the implementation project, conduct regular testing and system updates, and ensure a high level of data protection. Organizational risks are related to resistance to change on the part of employees, lack of qualified specialists to maintain the system and possible difficulties in adapting business processes to new conditions. To successfully overcomethem, it is important to conduct awareness-raising activities among employees, organize education and training, and develop clear instructions and methodologies for working with SED.

In order to further develop and improve this area, it is necessary to continue research aimed at identifying new opportunities and overcoming existing obstacles. Research and development of mobile applications for managing executive documentation at construction sites is a promising area. Such applications can greatly simplify and speed up the process of data collection, inspections and documentation directly at the study site. It will also improve communication and coordination between the various participants in a construction project. Studies on the cost-effectiveness of SED implementation will help justify investments in the digitalization of executive documentation. A detailed cost-benefit analysis of executive documentation system implementation and operation should be conducted to provide construction managers with a clear understanding of the financial outlook and return on investment. An important aspect of SED implementation is the adaptation of organizational processes and structures. Research to examine the impact of digitalization on organizational culture, structure and processes will help to develop strategies for successful change management. This will minimize employee resistance and ensure a smoother transition to the new work methods.

To summarize, implementing an executive documentation system is an important step towards digitalizing construction processes and making them more efficient. This allows construction organizations not only to meet modern requirements for quality and safety of construction, but also to significantly improve their business processes, reduce costs and increase customer satisfaction. An integrated approach to this challenge will ensure the successful implementation and use of digital technologies in the construction industry.

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