Management of the Design and Construction of Offshore Oil and Gas Facilities with Bim Base

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Abstract. The aim of the work is to improve the coordination of engineering processes in the creation of offshore oil and gas facilities and methods of managing the business processes of the operator's company. The concept of using the BIM (Building Information Modeling) system for the projects of offshore oil and gas facilities (OF) is presented. The main problematic aspects of implementing a large-scale project: the layout of technological equipment in a limited space; maintenance of accuracy of calculations; insufficiently effective application of PLM (Project Lifecycle Management) principles and data management in design and construction. The main routes are proposed, in accordance with which the modeling and management of engineering data is carried out. The structure of the information model and the algorithms proposed for its construction within the framework of the Russian design and construction system are developed. A tool is proposed that allows the company to the operator and subcontractors involved in the construction project to optimize their work and improve the quality of operating activities. The loss of time for communication and information retrieval for decision making is minimized, the burden on the project team members is reduced, the efficiency of the design and construction organization is significantly increased.

1. Introduction

When designing and building complex and unique facilities, which include offshore oil and gas platforms, significant material and human resources are involved. Often, companies do not manage to control both the technical and operation parts of the project simultaneously, resulting in errors, some of which lead to significant costs, and the cost of implementing a single OF project can reach hundreds of billion rubles.

At the stage of detailed design, procurement of equipment and construction of the offshore platform, there are inaccuracies or errors in design calculations, which requires making corrections to the project. With the existing methods of change management [1, 2] it is difficult to track the consequences of making adjustments to one or another part of the project, which can lead to an increase in the overall dimensions and mass of the equipment, the inability to place it in a designated place, use rare types of equipment with inflated prices. When completing the platform, specifying the required capacity leads to the adoption of forced technical solutions, for example, the introduction of additional temporary facilities.
In the process of analyzing the typical mistakes of the operator company involved in offshore production, we came to the conclusion that it is necessary to improve the interaction algorithms of the project participants and the algorithms for making technical and management decisions. It is proposed, in the course of design work, in parallel with the creation of a technical design of the offshore oil and gas facility, to plan and organize future project and design processes, to implement the principles of Project Integrity Management [3].

Two systems of distribution of roles and responsibilities within the operator's company are common in Russia. The first model is a domestic one, originating from the Soviet project management system [4, 5], under which all customer services bear responsibility, the main documents that entail financial responsibility are signed by all departments. At the same time, it is difficult to trace the sources and causes of the errors, and even more difficult to punish those responsible. The actual authorization of decisions is insufficient. The second model is practiced in our country relatively recently, when more attention was paid to building business processes within the company [6].

According to the second model, the roles and responsibilities are clearly distributed among the customer's related departments, and where possible, their duplication is avoided. At the same time, the burden on the departments is reduced, the quality of the project is improving, the participants are directly responsible for their work. Important in this division is to maintain the competitive principle of the work of related departments.

Serious problems arise at the junctions of the zones of responsibility, which can be formed both between technical systems that run sequentially in the process chain, and between zones of adjacent departments and customer services. When implementing each technological block of a structure, the technical analysis of the object should be used - interconnections between the subsystem and the supersystem are outlined, interrelations between certain technical parameters of the equipment units in the process chain and parameters affecting their magnitude are highlighted. After the technical analysis of the object, external relationships are fixed in the project information model to prevent errors when making changes to parameters or replacing equipment in the chain. The general protocol of technical analysis is attached to the data sheet for equipment for internal use when evaluating technical proposals from suppliers.

We introduce the concept of “Project route matrix” in the context of this article (hereinafter referred to as the matrix) - it is a logically formalized visualization of the main levels, processes, subjects, objects and their interrelationships in the project management system. When building a matrix, the main project implementation positions are initially planned, for which management levels are defined [7]. It is necessary to build relationships between the project entities (the project institute and the operator of the field operator), the project object (the offshore oil and gas facilities in general, the technological blocks in particular), the phases of the project (the types of activities that arise during the creation and implementation of the project) and the time frames project on the order of their implementation. The next step is planning the routing processes of the project implementation with reference to the main milestones. The process is carried out in parallel with the implementation of the technical project and is its integral part.

To visualize the process in the form of a "matrix" (Figure 1), a Exploitation and technological complex including the gas-lift gas preparation equipment on the injection platform was taken for the facility. As the subjects and applicants for the distribution of responsibility, the Customer's departments were included. The division into time segments is made according to the project execution plan.

After drawing up the structure of the "matrix", it is necessary to trace the routes of the design processes. Based on the received scheme, it is necessary to make changes in the trajectory of project processes, eliminate duplication of responsibility functions and identify areas of responsibility between the services of the operator's company. In the example under consideration, it is proposed to divide responsibility between the Division of Chief Mechanic and the Department of Exploitation maintenance of facilities.
The structure of the Operator Company (Subjects)

| Project office | Department of Chief Mechanic | Department of Chief Power Engineer | Department of Exploitation maintenance of facilities | Department of equipment | Holder |
|----------------|-----------------------------|-----------------------------------|-----------------------------------------------|------------------------|-------|
| Deputy CEO for Capital Construction | Project Implementation Unit | Department of design works and documentation expertise | CEO |

Object lifecycle

| Designing and Engineering | Transportation | Construction and installation | Maintenance | Re-equipment | Liquidation |
|--------------------------|---------------|-------------------------------|-------------|--------------|-------------|

Exploitation and technological complex (Object)

| Manifold for maintenance of reservoir pressure | Manifold for reservoir products | Gas lift compression unit | Methanol storage drum | Fuel gas conditioning unit |
|-----------------------------------------------|---------------------------------|--------------------------|----------------------|---------------------------|
| Gas lift manifold | Air receiver | Reservoir products storage drum | Gas-lift preparation unit |
| Gas lift cooling unit | Pumps of Hub | Pig launcher and receiver package | Reagent storage drum |
| | | | Nitrogen receiver |

Phase of project

| Initiation | Planning | Risk management | Fullfillment | Quality control | Analysis and control | Change management | Conclusions |
|------------|----------|----------------|-------------|----------------|---------------------|-------------------|-------------|

Time segments

| 1 stage | 2 stage | 3 stage | 4 stage | 5 stage |
|---------|---------|---------|---------|---------|

Figure 1. Structure of the project route matrix and an example of tracking project processes.

To manage engineering data, it is necessary to integrate the proposed "matrix" into the overall design process - creation of a project management system for complex process facilities. By means of digitalization of the process of designing and using the "matrix", relationships and dependencies are established between the technological units of the object in a single information space of the project [8]. In [9], the routes of the introduced project changes are examined in detail, and the mutual influence of the elements of the platform information model (IM) on adjacent elements of the structure is visually monitored, it is possible to trace the routes of the introduced changes to the project and to find out the mutual influence algorithms of the information model components.

When designing the IM assumes the stage of project implementation throughout the life cycle of an object, for which it is appropriate to use a 3D model implemented by the corresponding software and, accordingly, an information model. Such manipulations are carried out under the control of PDM (Product Data Management) tools, as an integral part of the implementation of the information model. The paper [10] shows the process of constructing a constructive part of the offshore fixed platform and the relationship with the location of the platform's technological modules.

The process of managing changes in project content allows you to track who, when and what changes were made to the information model, determine the access rights for each design participant. Thanks to the technology of information modeling, much less time and material resources are spent on
the implementation of the project [11]. The information model provides a visual representation of the process of carrying out design work [12].

Thus, we can talk about the creation of a methodology for organizing the design and construction of offshore oil and gas facilities that solves the problems of change management arising from the implementation of projects of complex process facilities.

Engineering data management is performed on the BIM platform. BIM, as a technology of information modeling of industrial objects, formalizes the process of data management in the information space of the project [13]. A number of scientific publications and standards [14] consider the advantages of software complexes based on the BIM platform for the design of complex technical objects [15] and OF in particular [16]. The technology includes three-dimensional modeling, automatic drawing of drawings, intelligent parameterization of objects, the corresponding sets of design data, the distribution of the construction process in time stages, etc. BIM covers the main stages of the life cycle of the structure: planning, drafting of technical specifications, design and analysis, issuing of working documentation, construction, operation and maintenance, re-equipment, dismantling. In work [17] experience of application of technology BIM is presented with the purpose of reduction of expenses for the utilization which have served the life time, platforms in the Gulf of Mexico.

In Russia, this system is introduced at the state level - the Plan for the phased implementation of BIM (Order of the Ministry of Construction of Russia No. 926 / pr dated December 29, 2014). The authors [18] distinguish several ways of introducing BIM - political, commercial and technological, each of which is found in a certain local market.

The final results from the implementation of the information modeling system are evaluated against the criteria of the maturity model [19] of the final level for the information model of OF built in the BIM environment. A digital project with aligned interrelations is transferred to the operator, which, with the help of it, manages the life cycle of the structure and other design processes. The information model is an instrument for predicting possible collisions and most effective elimination of them.

The proposed approach allows us to restructure the system of distribution of powers and responsibilities in the company without attracting additional resources, avoid repeating the mistakes in the future, increase production indicators, and reduce capital investments in OF projects.

The end result is the matrix of distribution of authority and responsibility for decision-making between the services of the operator and contractors involved in the design and construction of OF; proposals on the algorithm for effective project management and optimization of the distribution of roles and responsibilities between project participants.

Reference

[1] American Bureau of Shipping 2013 Guidance notes on Management of change for the Marine and Offshore Industries (Houston: American Bureau of Shipping)
[2] Rasendahl T, Egir A, Due-Sørensen L K, and Ulsund H J 2012 Integrated Operations: Change Management in the Norwegian Oil and Gas Industry Beta (Oslo:Universitetsforlaget) vol 26 Iss 1 pp 40 – 63
[3] Exxon Mobil Corporation 2009 Operations Integrity Management System (Irving: Exxon Mobil Corporation)
[4] Buslenko N P, Kalashnikov N N and Kovalenko I N 1973 Lekcii po teorii slozhnyh sistem (Moscow: Sovetskoe radio)
[5] Volkovich V L and Radomskij N F 1971 Sistennyy podhod k issledovaniyu ierarhicheskikh sistem upravleniya Ustoichivost’ i kolebaniya nelinejnyh sistem upravleniya Int., Conf. (Baku:IPU)
[6] Ilin I V and Levina A I 2013 The Integration of the Project Management approach into the Business Architecture model of the Company St. Petersburg Polytechnic Journal.Economics vol №6-2 (St. Petersburg: St. Petersburg Polytechnic University) pp 74-82
[7] Bezkorovaynyy V P, Voropaev V I and Sekletova V I 1999 Metodicheskij podhod k formirovaniyu predmetnoj oblasti bol'shih korporativnyh sistem upravleniya Proc. Int. Symp. Project Management (Moscow)

[8] Bezkorovaynyy V P and Drozdov S V 2012 Engineering of standard unified informational space of oil and gas projects realization Automation, telemechanization and communication in oil industry (Moscow: VNIIOENG) Iss 8 pp 15–21

[9] Bayazitov V D and Bezkorovaynyy V P 2017 Managing construction of marine oil-gas facilities within united informational space Vesti gazovoy nauki (Moscow: Gazprom VNIIGAZ LLC) Iss 4 pp 169–172

[10] Bezkorovaynyy V P and Bayazitov V D 2018 Model of managing project processes for design offshore oil and gas facilities Proc. of Gubkin Russian State University of Oil and Gas (Moscow: Gubkin Russian State University of Oil and Gas) Iss 1 pp 91–97

[11] Bayazitov V D 2017 Creation of the Information Modeling system for Offshore facilities projects Proc. of RAO/CIS Offshore 2017 (St. Petersburg: HIMIZDAT) pp 329–32

[12] Bezkorovaynyi V P and Bayazitov V D 2017 Quality Control of the Offshore Facilities Project with the Technology of Information Modeling Quality Management in Oil and Gas Industry (Moscow: LLC National Institute of Oil and Gaz) Iss 3 pp 15–18

[13] Hardin B and Cool D BIM and construction management: proven tools, methods, and workflows. 2nd ed. (Indianapolis: John Wiley &Sons Inc.)

[14] National Institute of Building Sciences building National BIM Standard - United States Ver. 2 (Washington: National Institute of Building Sciences building)

[15] Zarubin P E, Baranovskij M Y, Tarasov V A 2013 Tekla Structures – is innovation of structures’s Internet Journal Construction of Unique Buildings and Structures (St. Petersburg: St. Petersburg Polytechnic University)

[16] Gabova V V, Degtareva D S, Kim D A 2017 3D modeling of oil and gas facilities in the MicroStation program Electronic scientific journal Engineering Journal of Don (Rostov-on-Don: North-Caucasus scientific center of high school of Southern federal university) Iss 4 pp 63–70

[17] Tan Y, Song Y, Wang X, Cheng J 2017 A BIM-based framework for lift planning in topsides disassembly of offshore oil and gas platforms Automation in Construction (Amsterdam: Elsevier) Iss 79 pp 19–30.

[18] Succar B and Kassem M 2015 Macro-BIM adoption: Conceptual structures / Bilal Succar, Mohamad Kassem // Automation in Construction (Amsterdam: Elsevier) Iss 57 pp 64–79.

[19] AVEVA Solutions Limited 2016 Reaching Level Five: A Roadmap Tool for Owner Operators (Cambridge: AVEVA Solutions Limited)