ISSN: 3079-6369

Discussion on the System Reconstruction and Efficiency Enhancement of Oil and Gas Field Engineering Cost Management from the Perspective of Digital Empowerment

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Abstract

In the current complex and challenging economic environment, as well as in the context of increasingly fierce industry competition and the emergence of numerous new characteristics and requirements in industry development, many oil and gas field enterprises are actively and proactively promoting the continuous advancement of engineering cost management in their practical operations. However, inevitably, they will encounter a series of practical and urgent problems that are extremely difficult to handle. The existence of these problems and difficulties significantly hinders the smooth implementation of oil and gas field engineering cost management and the effective improvement of management level and quality. This paper will precisely and clearly focus its research perspective on the specific application of digital technology in the specific and crucial field of oil and gas field engineering cost management, and will conduct a comprehensive, in-depth, and meticulous discussion and research around this core theme. It is expected that through the comprehensive, in-depth, and meticulous research and analysis presented in this paper, it will provide useful references and guidance for oil and gas fields in their digital transformation of engineering cost management, and help them achieve orderly, stable, and efficient development during this transformation process.

Keywords

Digital technology; Oil and gas fields; Engineering cost management; Efficiency.

1. Digital Technology Facilitates the Whole Process Management of Engineering Cost

1.1. Deep Application of Digital Technology in Engineering Budget Preparation

Oil and gas field enterprises fully and deeply utilize the powerful information processing capabilities and deep mining capabilities of big data technology to conduct systematic, detailed and in-depth analysis and mining of massive and complex historical engineering data. In this rigorous and interlocking process, oil and gas field enterprises gradually successfully build a rich and diverse cost database that covers various key information. Based on the extremely rich data resources contained in this database, oil and gas field enterprises can accurately and sensitively observe the fluctuation patterns of material prices and quickly and accurately identify those cost risk factors hidden behind the massive data that may have a significant impact on engineering costs. This advanced architecture breaks through geographical limitations, enabling budget preparers in different regions and positions to collaborate efficiently through this platform.

ISSN: 3079-6369

1.2. Comprehensive Optimization of the Bidding and Tendering Process by Digital Technology

During the bidding and tendering process of oil and gas field enterprises, they introduce intelligent contract technology with an innovative attitude, strictly implementing the bidding rules in a highly programmed and precise manner. This programmatic execution mode based on intelligent contracts can significantly reduce potential risks caused by human intervention and effectively prevent deviations and unfairness in rule execution due to subjective factors. At the same time, it significantly enhances the standardization and traceability of the entire bidding and tendering process, ensuring that every operation in the bidding and tendering activities leaves detailed, accurate and verifiable records, thereby ensuring that the bidding and tendering activities can be smoothly and orderly carried out in a fair, just and open environment. In the scoring section, the system conducts precise and error-free calculations strictly according to the set rules, completely free from interference by human emotions and subjective factors, thereby greatly enhancing the objectivity of the bid evaluation results.

1.3. Application of Innovative Digital Technologies in Project Implementation and Settlement Processes

By leveraging big data platforms and advanced sensor equipment, real-time and precise collection of engineering progress data can be carried out. These sensor devices are reasonably and orderly distributed at various key locations on the construction site, enabling accurate and timely acquisition of various information related to the engineering progress. Oil and gas field enterprises use the collected data to build digital twin models, which can truly, comprehensively and dynamically reflect the actual situation of the construction site, thereby enabling visual monitoring of the construction process and allowing managers to have a clear understanding of the progress status. Through timely warnings and in-depth analysis of these risks, oil and gas field enterprises can provide scientific and reasonable decision-making basis for dynamic cost control, adjust the cost plan in a timely manner based on actual circumstances, and ensure that the project cost remains within the controllable range. For example, when the project reaches a pre-set milestone or completes a specific task, the system will automatically perform settlement calculations based on contractual agreements and relevant data. This mechanism significantly improves the efficiency and accuracy of settlement, effectively reduces human errors and settlement cycles, saves a lot of time and costs for oil and gas field enterprises, and thereby enhances the economic benefits of oil and gas field enterprises.

2. Construction of Digital Engineering Cost Management System

2.1. Establishment of Digital Cost Management Platform

For oil and gas field enterprises, building a digital cost management platform that is both comprehensive and efficient is of utmost significance. This platform can achieve effective and precise control over the entire life cycle of the project, from planning, design, construction to completion, by leveraging the three different levels of the data layer, application layer, and interface layer that hold key positions and play core roles (please refer to Figure 1 for details) [1].

During the construction process of the data layer, oil and gas field enterprises need to fully utilize the advanced technology of distributed database to build a unified data warehouse. By taking this measure, on the one hand, it can ensure that the cost data is stored in a unified and standardized format, making the data consistent and standardized at the format level, effectively avoiding processing difficulties and information chaos caused by differences in data formats; on the other hand, it can achieve real-time sharing of cost data, ensuring that staff in different departments and personnel in different positions can obtain the required data

ISSN: 3079-6369

promptly and conveniently when there is a data demand, thereby improving work efficiency and enhancing the value of data utilization.

In the construction process of the application layer, oil and gas field enterprises, based on the flexible and efficient technical framework of microservice architecture, will scientifically and flexibly combine these functional modules, adjust and optimize the platform functions according to different business requirements and actual application scenarios, so as to meet diverse business processing requirements.

In the construction of the interface layer, oil and gas field enterprises need to do the following three things effectively. First, formulate a standardized data exchange protocol, clearly and detailedly stipulating the format, rules and processes of data interaction in this protocol, so as to ensure that different systems and platforms can accurately and smoothly exchange data when conducting data exchange, avoiding system failures and information errors caused by problems in data interaction. Second, develop highly compatible interface modules, using this module to promote the deep integration and smooth interaction connection between the digital cost management platform and Building Information Model (BIM), oil and gas field enterprise resource planning (ERP) system, so that the data between various systems can achieve interconnection, thereby improving the liquidity and sharing of data. Third, strengthen the synergy between protocols and interfaces, by optimizing the cooperation mode of protocols and interfaces, ensuring that multi-source data can interact in an efficient manner, achieving close linkage between different businesses, and further improving the efficiency and coordination of the entire engineering cost management work, creating greater value for oil and gas field enterprises.

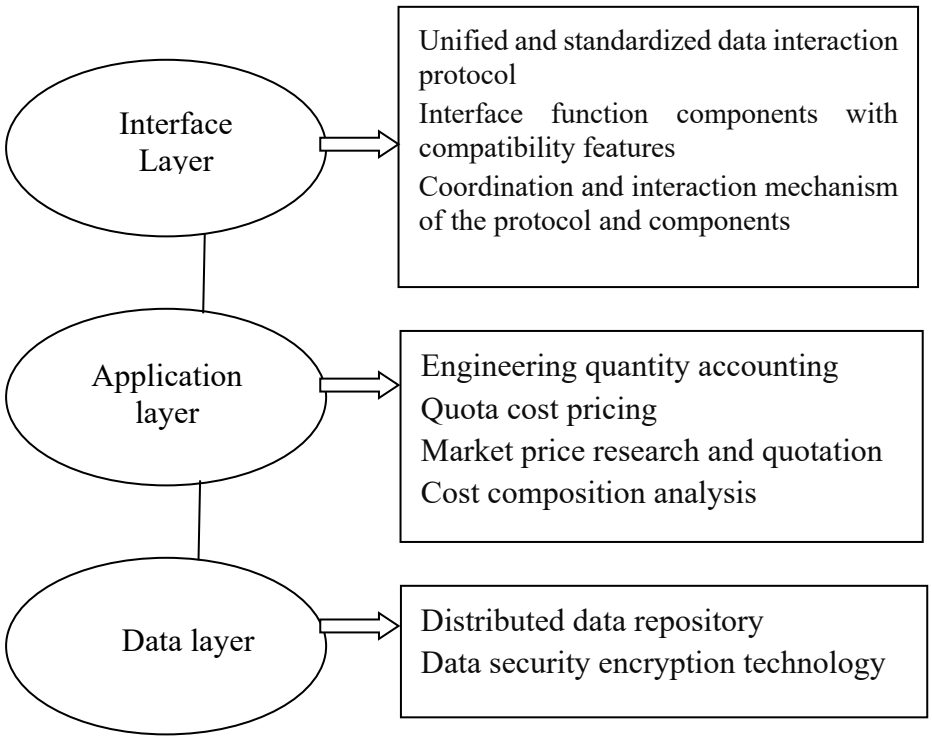

Figure 1: Architecture Diagram of Digital Cost Management Platform

ISSN: 3079-6369

2.2. Establishing a Data Standard System and Creating a Knowledge Graph

For oil and gas field enterprises, actively leveraging the construction of a data standard system and a knowledge graph is a crucial measure to drive digital engineering cost management to a higher level and better quality. At the level of data standard system construction, oil and gas field enterprises need to establish a data standard system that comprehensively covers four core and crucial elements: classification standards, coding rules, exchange formats, and quality standards. This system will play an extremely important regulatory role, enabling comprehensive, detailed, and in-depth regulation of data from the initial collection stage, through the intermediate storage stage, to the final processing flow.

In terms of knowledge graph construction, oil and gas field enterprises should, using the ontological modeling method, which combines scientificity and efficiency, start to build a knowledge graph in the field of cost. Specifically, a three-level structured system consisting of the concept layer, entity layer, and relationship layer needs to be constructed. This will enable a systematic, orderly, and hierarchical organization and presentation of professional knowledge and rich and complex experience rules in the field of cost. This structured expression method can make knowledge clearer, easier to understand and apply, thereby significantly improving the scientificity and accuracy of engineering cost management, making it more in line with actual situations and market demands. See Table 1 [2].

Table 1: Key Elements and Functions for Building the Cost Knowledge Graph

Dimension	Content Description	Function Manifestation
Construction Method	Building the cost knowledge graph using ontological modeling methods	Provides a scientific path for graph construction, ensuring reasonableness and professionalism
Structural System	Establishing a three-level structured system comprising concept, entity, and relationship layers	Systematically organizes cost knowledge and rules, presenting them hierarchically for easy understanding and application
Final Outcome	Enhances the scientific precision of cost management, aligning with reality and the market	Optimizes cost management, ensures decisions fit reality, improves benefits and competitiveness

2.3. Establish a multi-party collaboration and information security guarantee mechanism

In terms of establishing a multi-party collaboration mechanism, oil and gas field enterprises need to define the responsibilities and interaction rules of each participating party clearly and precisely with a clear and rigorous attitude. In terms of establishing an information security mechanism, oil and gas field enterprises should attach great importance to the issue of information security and build a four-layer rigorous and complete protection framework consisting of identity authentication, permission control, data encryption, and behavior auditing. The identity authentication mechanism can ensure that only users with strict authorization can access the system; the permission control mechanism can finely divide the access rights of different users to prevent unauthorized access by users; the data encryption mechanism can encrypt important data, so that even if the data is stolen, it cannot be easily interpreted; the behavior auditing mechanism can record and audit the user's operation behaviors in detail, and promptly detect abnormal behaviors and take corresponding measures.

ISSN: 3079-6369

2.4. Improve the system integration and business collaboration operation mechanism

Firstly, oil and gas field enterprises should rely on the advanced and efficient technical architecture of the unified oil and gas field enterprise service bus (ESB) to build cross-system data exchange channels. The unified oil and gas field enterprise service bus has strong integration capabilities and can achieve interconnection between different systems, enabling each system to share data resources and achieve collaborative work, thereby improving the overall operational efficiency of the oil and gas field enterprise. Secondly, oil and gas field enterprises need to establish a dynamic linkage mechanism between cost data and financial accounting, budget management, and capital planning. Through this mechanism, it can provide strong data support for precise cost control. Oil and gas field enterprises can adjust financial accounting methods, budget plans, and capital arrangements in a timely manner based on real-time cost data, enabling the oil and gas field enterprise to more accurately grasp the cost situation and make scientific and reasonable decisions. Finally, oil and gas field enterprises should implement cross-system data quality management strategies, starting from the data source, conducting strict and meticulous quality control of data collection, entry, storage, transmission, etc., so that the oil and gas field enterprise can achieve the goal of digital engineering cost management under the support of a stable and efficient information system, and enhance the core competitiveness of the oil and gas field enterprise.

3. In-depth Analysis of the Efficiency of Digital Engineering Cost Management

3.1. Comprehensive Analysis of Economic Benefits and Cost Reduction

In the key and core area of cost control involving human resources in oil and gas field enterprises, oil and gas field enterprises have demonstrated an active and pioneering innovative attitude, vigorously introducing advanced digital technologies and a wide variety of digital tools to achieve more precise and efficient management and control of human resources costs. In the aspect of material procurement cost control, which is extremely important for the cost control of oil and gas field enterprises, oil and gas field enterprises fully leverage the powerful advantages and functions of big data analysis technology. By deeply and meticulously exploring and analyzing multi-dimensional and multi-level information such as historical data, market trends, and project requirements, oil and gas field enterprises can achieve precise and error-free predictions of material demands, and can also monitor the fluctuation of market prices in real time and dynamically, thereby providing a strong basis for procurement decisions.

In construction management, oil and gas field enterprises actively adopt cutting-edge digital twin technology. By constructing virtual models that are highly matched with the actual scene, the enterprise can conduct comprehensive and refined simulation and rehearsal of the construction process in the virtual environment. This innovative management approach enables the enterprise to anticipate potential conflicts and problems in advance, such as pipeline collisions of different specialties, unreasonable construction sequence causing project delays, and spatial layout conflicts leading to construction difficulties. During project implementation, the enterprise can quickly and accurately adjust the plan and optimize the process based on model warnings, significantly reducing design changes and rework, and reducing costs while improving efficiency. Digital delivery is the cornerstone for enterprises to move towards intelligent and efficient construction management. By leveraging digital tools and information technology, enterprises create virtual models that integrate project lifecycle data, forming a complete, accurate, and dynamically updated digital asset library. Intelligent construction sites are the vivid practice of digital twin technology in the oil and gas field site. From foundation construction to equipment installation, each link is presented realistically in

ISSN: 3079-6369

the virtual space, opening up a window for the enterprise to "see the future", helping it see details, identify risks, and provide support for construction management decisions, and improving quality and efficiency. In order to more intuitively and accurately verify the significant efficiency achieved by digital engineering cost management, this article selects a certain oil and gas field enterprise as a typical case for in-depth research. The relevant data is clearly presented in Table 2 [3].

Table 2: Comparative Analysis of the Application Before and After Establishing a Digital Engineering Cost Management System in an Oil and Gas Field Enterprise

Unit: *Ten thousand yuan/year*

Evaluation Perspective	Labor Cost	Material Procurement Cost	Construction Management Cost
Traditional Mode	110	880	400
Digitalized Mode	40	700	275

3.2. Construction and Application of the Innovation Technology Value Evaluation System

In the current context where the digital upgrade wave is surging with overwhelming momentum and unstoppable force across various industries, oil and gas field enterprises, leveraging the powerful driving force and favorable opportunities bestowed by this era, have already established a solid foundation and favorable conditions for building a set of innovation technology application value evaluation system with higher accuracy and more comprehensive, detailed and in-depth features.

Regarding the extremely important dimension of technical applicability assessment, oil and gas field enterprises can fully utilize various advanced technological tools emerging in the digital era to conduct in-depth and meticulous data field mapping work on the technical logic contained in the innovation plans and the currently running and relatively mature existing cost management processes of the oil and gas field enterprises. On this basis, they can further carry out comprehensive and highly realistic business process simulation operations.

In the value creation assessment dimension, oil and gas field enterprises can actively introduce the balanced scorecard method, which is widely recognized and highly authoritative in the management field. Using this method as an important support, they can meticulously construct a comprehensive evaluation model from four different but interrelated and mutually reinforcing aspects: financial benefits, customer satisfaction, internal processes, and organizational learning. This comprehensive evaluation model is like a highly accurate and reliable "value scale", capable of conducting systematic, comprehensive and in-depth quantitative analysis of the actual application effects of blockchain, BIM and other innovation technologies in engineering cost management.

3.3. Analysis of Management Efficiency Enhancement

In the critical and core area of decision support, oil and gas field enterprises can fully utilize historical data for in-depth and systematic analysis, and use predictive models for forward-looking deductions and predictions. In the process management section, oil and gas field enterprises leverage the strong power of digital technology to build a visual monitoring system covering the entire construction cycle without any blind spots. This system is like a comprehensive and unmissable "electronic eye", capable of capturing real-time data information at key nodes such as list preparation and visa changes and synchronizing it accurately to the management platform. In terms of risk management, oil and gas field

ISSN: 3079-6369

enterprises further deepen the application of digital technology, establishing a modern risk identification and assessment mechanism, as shown in Table 3 [4].

Table 3: Analysis of the Enhancement of Digital Engineering Cost Management Efficiency in an Oil and Gas Field Enterprise

Management Efficacy Enhancement Dimension	Specific Measures	Data Presentation
Decision Support	Utilizing historical data analysis and predictive models for forecasting	Historical data utilization rate increased to 85%; predictive model accuracy reached 80%
Process Management	Establishing a full-cycle visual monitoring system with digital tech, syncing key node data	Key node data synchronization rate reached 95%; monitoring coverage achieved 90%
Risk Management	Deepening digital application, pre-setting risk indicators for risk assessment	Risk identification accuracy reached 90%; quantitative assessment error rate < 10%

By setting up a series of representative risk indicators such as engineering quantity deviations, price fluctuations, and policy changes, oil and gas field enterprises can accurately identify and quantitatively assess various risks in the project, thereby providing a strong guarantee for the smooth progress of the project.

4. Conclusion

Digital technology is exerting an unprecedentedly powerful force to deeply and comprehensively reshape the original underlying logical framework of engineering cost management. It is vigorously driving the entire industry to accelerate and irreversibly transform from the previous management model that relied on traditional "experience-driven" methods towards a "data-driven" model with data as the core element. Facing the future filled with opportunities and challenges, oil and gas field enterprises, when conducting engineering cost management work, need to closely rely on the two-way driving mode of technological innovation and management innovation, which are mutually coordinated and mutually promoting. They should continuously and firmly move forward steadily towards the intelligent direction. By applying advanced data analysis algorithms and models to improve the prediction ability of engineering cost-related factors, oil and gas field enterprises can provide more reliable, accurate cost control guarantees and scientific and reasonable decision support for the entire life cycle of the project from planning, design, construction to operation. Thus, in the new development wave of the intelligent construction era, they can seize the development initiative and firmly win the initiative in future market competition.

References

[1] SHI H F. Research on the rationality review of construction engineering cost based on data mining[J]. CONSTRUCTION AND BUDGET, 2024(9): 36.

[2] DONG Q. Research on Optimization Measures and Innovative Methods in Cost Management of Construction Projects[J]. SCI-TECH INNOVATION& PRODUCTIVITY, 2023, 44(4): 77-79.

[3] ZHANG B Y, GAO Y W. Analysis of Engineering Audit Risk Identification and Evaluation Based on Data Mining[J]. Applications of IC, 2024(4): 12-14.

[4] GAO Q. Calculation method for power grid infrastructure engineering cost based on data mining technology[J]. Popular Utilization of Electricity, 2024(7): 54-56.

ISSN: 3079-6369

[5] LI X Y. On the Innovative Measures of Civil Engineering Cost Management[J]. Jiangxi Building Materials, 2021(8): 279-280.

[6] WU J X. Analysis of innovation in construction engineering cost management[J]. Housing and Real Estate, 2020(9): 14.